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PROCESS DEVELOPMENT--TUNGSTEN HEMISPHERES.(U)
APR 80 DAAK10-79-C-0049
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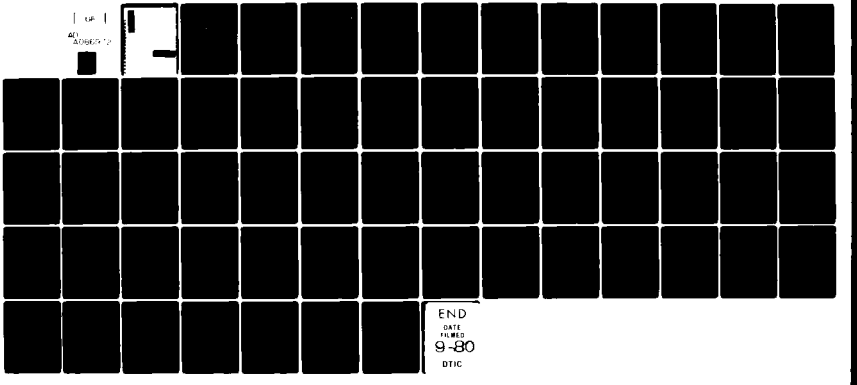

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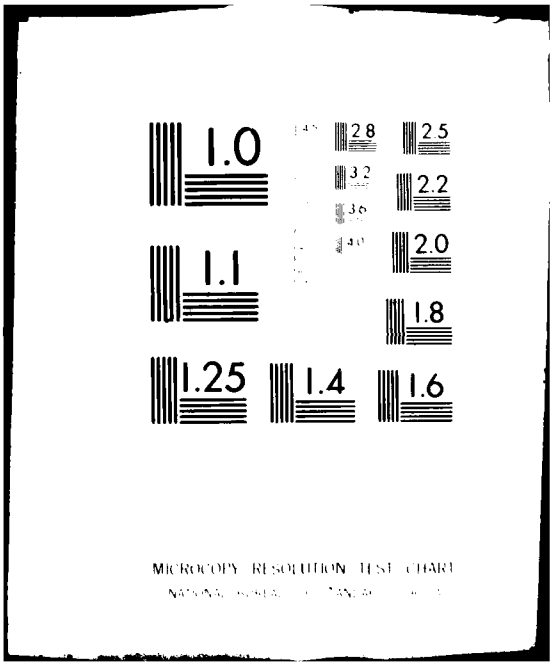
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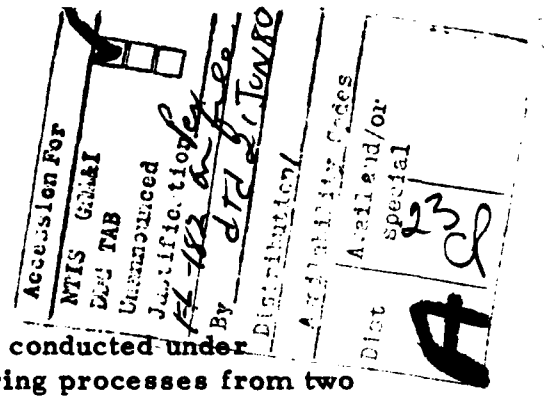

I. INTRODUCTION

This report presents the summary of activities conducted under DAAK10-79-C-0049 to develop two separate sintering processes from two tungsten manufacturers that have years of experience and expertise in the field of tungsten powder metallurgy. The objectives of this development program was to:

1) Lower the scrap rate due to cracking to 1 - 2%.

2) Improve material quality (reduce or eliminate porosity).

3) Develop an "as sintered" product that had a ductility of 25%.

4) Produce an "as sintered" tungsten disc with a collar i.e., eliminate the fragment lines near the outer edge of the disc.

5) Qualify two heavy metal suppliers of tungsten discs for follow-on large quantity production.

Several changes were made to the sintering and forming processes from the previous 2400 part contract and are identified as follows:

1) Disc diameter was changed from 3.436 to 3.625 to accomodate an unscored collar.

2) The surface finish was changed from 64 to 250 microinch.

3) Ductility was changed from 22% to 25% (A change was subsequently allowed on Kennametal hardware of 18%.

4) The 80° $^{+5^{\circ}}$ fragment angle was changed to 80° $^{+10^{\circ}}$.

5) The 50° $^{+5^{\circ}}$ fragment angle was changed to 50° $\pm 5^{\circ}$.

6) A new forming die insert was provided to accept the larger diameter discs.

This contract required that two subcontractors participate in this development. The two participating companies were:

Kennametal Corporation	Teledyne Firth Sterling
Latrobe, Pennsylvania	Nashville, Tennessee

The initial program schedule is shown in figure 1. Each contractor began disc development in January, 1980. The final schedule is shown in figure 2. The tungsten discs were developed and processed to the following requirements that are presented in Appendix B.

1) Material Specification 707-111

2) Disc, Tungsten 9313567

In addition, each contractor was required to submit a Manufacturing Methids Report (DI-P-1604-Tailored). This report is identified in Appendix B.

II. DISCUSSION

Based on the forming problems experienced during contract DAAK10-77-C-0221 for 2400 parts, this process development program was initiated to meet the objectives stated in the previous paragraph. It was required by Specification 707-111 that each contractor submit ten peices for first article inspection approval prior to producing the remaining 170 pieces. Each contractor had problems initially of meeting the tolerance requirements on the fragment side of the disc and consequently, each had to redesign and fabricate a second compacting die. The discs received from the second compacting efforts were thereafter dimensionally acceptable. The ductility requirement of 25% was met by Teledyne Firth Sterling but was not met by Kennametal. A letter of deviation shown in Appendix E (DRDAR-PRW-B, dated 27 November 1979) was received allowing a ductility of 18% for Kennametal hardware. The performance events for each contractor are as follows:

Teledyne Firth Sterling

- The first article inspection covered 32 discs that were formed in latter March, 1979. The initial discs were formed at a temperature of 750°F since Vought conducted tests showing that ductility increased from 27.4% at ambient temperature to 41% at 750°F. The forming process planning instructions were changed from 650°F to 750°F.

- Five of the 32 parts were formed in the new forming die. The forming radius was 0.687 inch and the locating diameter was 3.633 inch diameter (to accept the larger disc diameter of 3.625 inch). The collared areas wrinkled excessively on the first two parts. The die

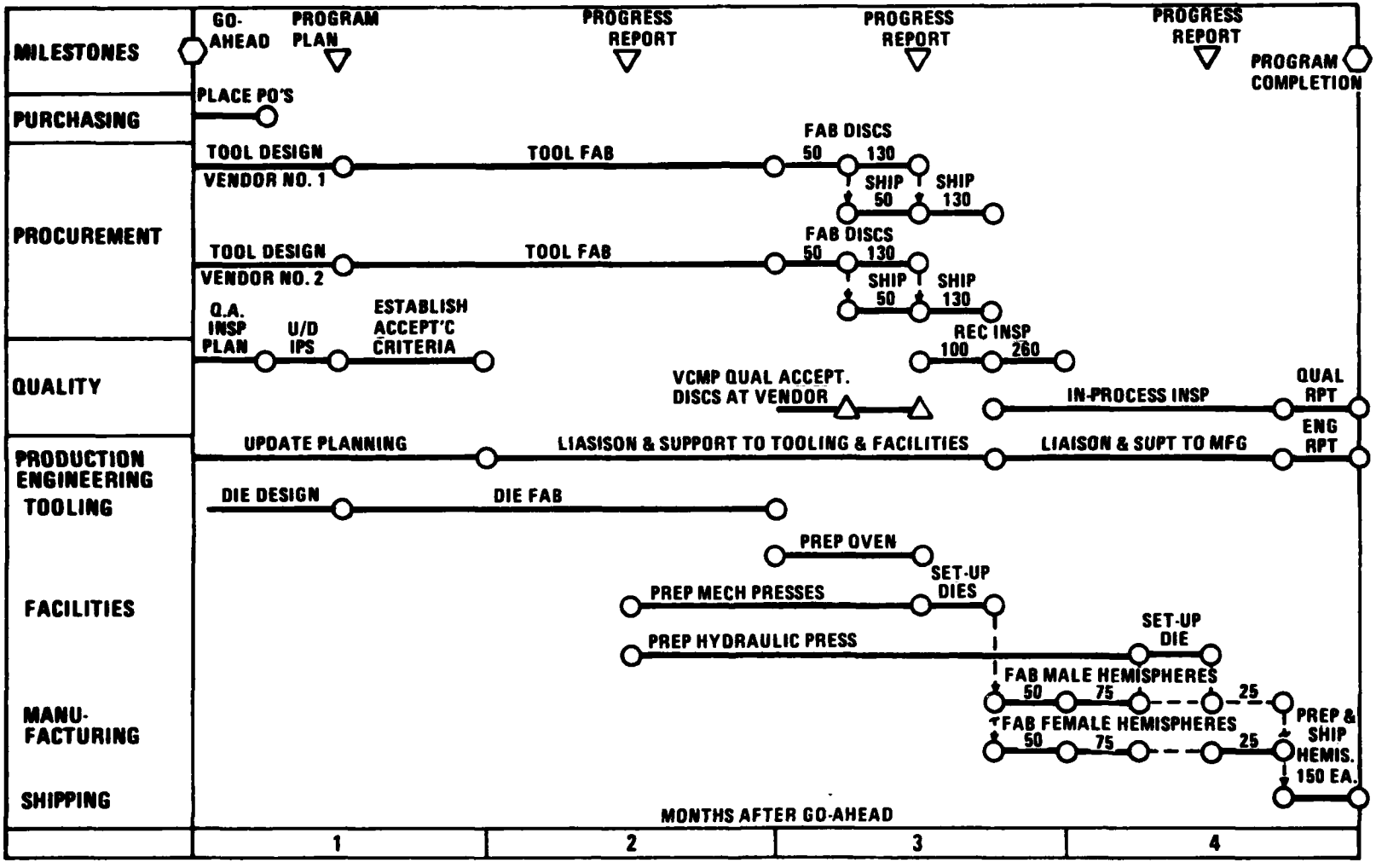

Figure 1. Tungsten Hemispheres Process Improvement Schedule.

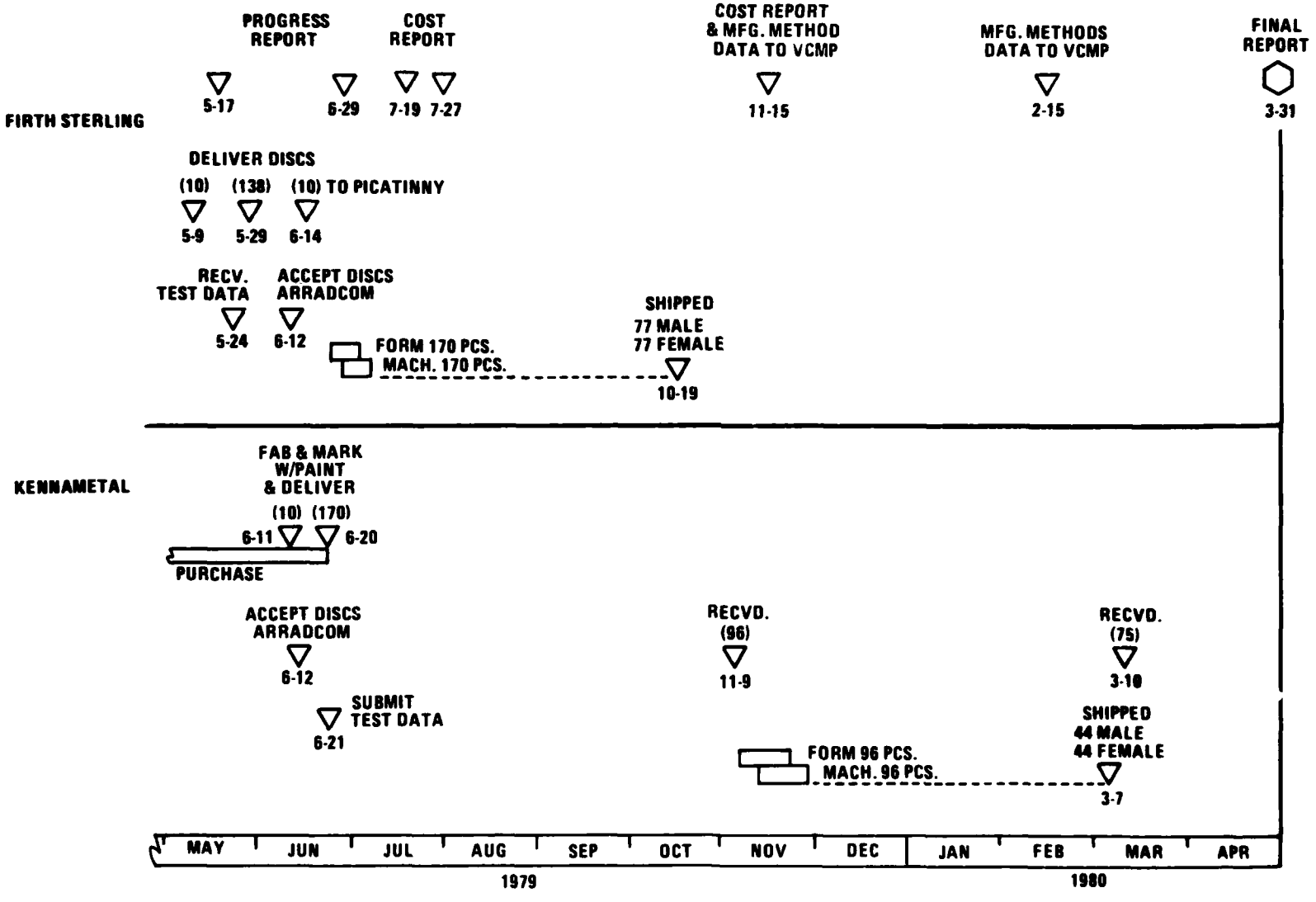

Figure 2. Process Development Schedule for Tungsten Hemispheres (DAAK 10–79–C–0049).

stroke was reduced 0.050 inch for each of the next three parts for a total decrease of 0.150 inch. All three parts also showed excessive wrinkling.

- It was decided to machine the collar to the original diameter of 3.436 inch and install a machined washer in the die to accommodate the 3.436 diameter. The remaining parts were formed and met all of the drawing requirements. The contractors were notified to supply discs machined to the 3.436 inch diameter. The remaining 138 parts received from Firth Sterling were formed and machined and 154 of the total were delivered. Ten discs were delivered unpressed to ARRADCOM and the remaining parts were scrapped during die set up and machining set up.

Kennametal Corporation

- The first article inspection was conducted at the Kennametal plant in Latrobe, Pennsylvania on April 16 and 17, 1979. A total of 24 discs were completed at that time. Of the 24 parts, only six were processed at the same temperatures, stoking rates etc. The other 18 discs were termed experimental and were not considered uniform enough for first article approval. Three parts had been 100% inspected and failed to meet the dimensional requirements due to an 18% shrink rate. The compacting punch was designed for a 20% shrink rate. A new punch was fabricated and a first article inspection was completed on 10 discs at the Vought facility in mid June 1979. The $0.100^{-0.010}$ and 0.139 ± 0.003 dimensions were not within print and the ductility checked only 18% and 21% on two separate tests. The hardware was approved for forming by ARRADCOM. The forming results are:

  4 Male acceptable
  1 Male defective - edge crack
  3 Female acceptable
  2 Female defective - edge cracks

- A follow on shipment of 96 discs was received from Kennametal in November 1979, and was approved for forming by ARRADCOM (Letter DRDAR-PRW-B shown in Appendix). One disc was sectioned for mechanical testing and the remaining 95 discs were formed in February, 1980. Five hemispheres were rejected due to edge cracks, 46 females and 44 males were delivered to the Milan Army Ammunition Plant in March, 1980. The remaining 75 discs were received from Kennametal too late to process and are being shipped to ARRADCOM as received.

- Of the 96 discs received, 47 were heat treated and 49 were as sintered. At a forming temperature of 750°F, no differences were noted between the two conditions. The ductility of the as sintered disc was 18% - 18.5%.

- The stroke setting at the forming press is 1.70 inches (average).

III. KENNAMETAL CORPORATION PROCESS DESCRIPTION

In producing the material for the tungsten disc, Kennametal purchased ore concentrate to convert to tungsten powder and sent the concentrate to a subcontractor for processing to ammonium paratungstate. The flow chart is shown in figure 3.

The ammonium paratungstate is converted to tungsten tri-oxide in a continuous belt type furnace by controlling temperature and time. The tungsten tri-oxide is converted to tungsten powder in an atmosphere controlled continuous belt furnace. By controlling the temperature and speed of the belt under a reducing atmosphere of hydrogen, tungsten powder of proper particle size is produced.

Blending

The powders (composition is shown in the Appendix) are then screened and blended in a ball mill. A Sun Oil Company wax is used in the powder blend. After ballmilling, the powder is fitzmilled to break up agglomerates and re-blended.

Compacting

After blend analysis, the powder is pressed in a 250 ton Alpha press. The powder is weighed and placed into the die cavity and hand leveled to fill all areas of the die cavity. The top punch descends into the die cavity and at approximately 250 tons, dwells (de-airs the compact) and is raised. Ejection is completed hydraulically by raising the compact from the die cavity and manually removing the compact from the press.

Delube

A Westinghouse Glow Bar, 2 Zone Furnace is used for delubing the discs. The furnace is capable of processing 24 discs/hour in an inert atmosphere of disassociated ammonia at a flow rate of 300 cubic feet to 500 cubic feet per hour. The discs are loaded into boats which are placed onto trays and pushed through the furnace at a rate of one tray/hour.

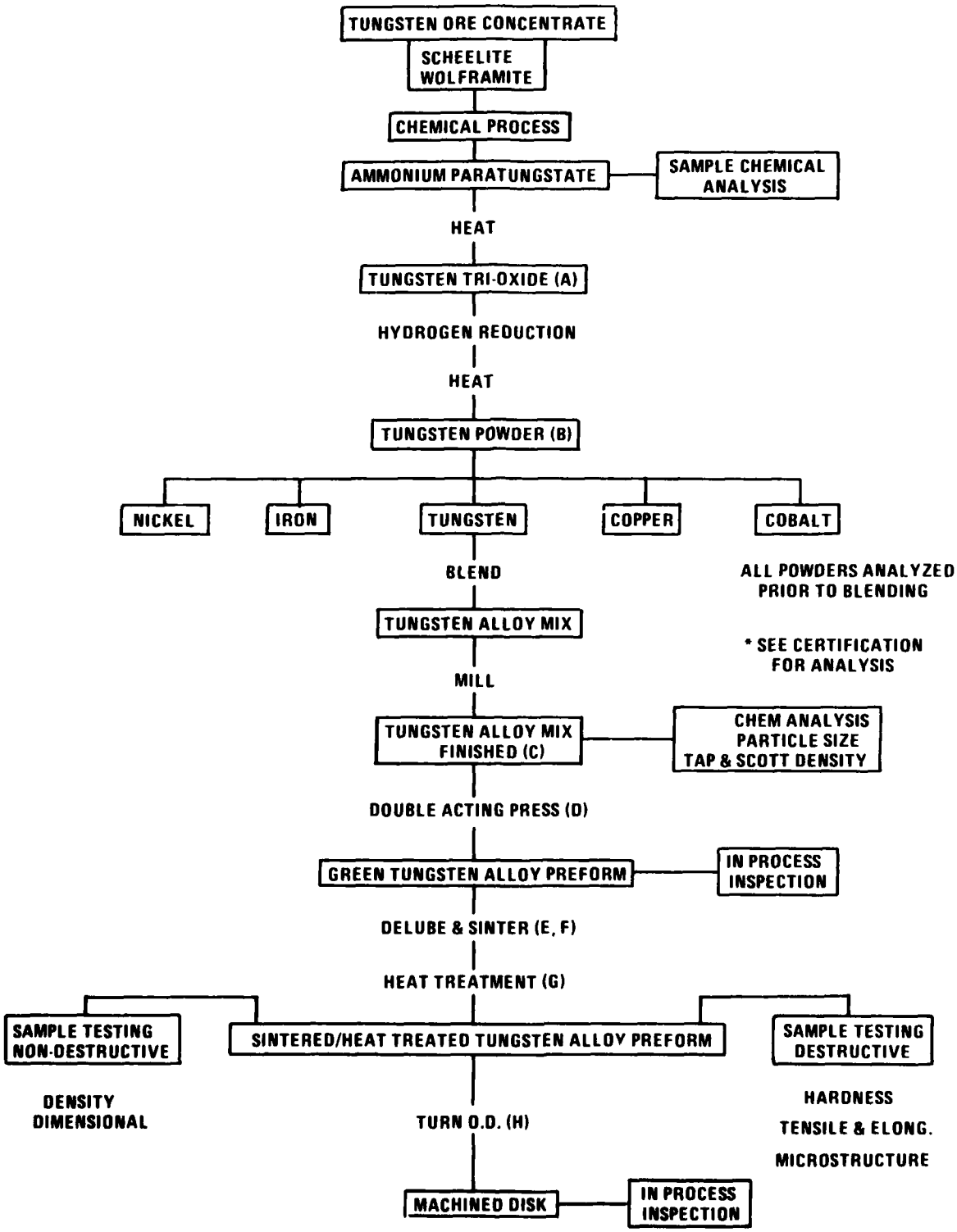

Figure 3. Manufacture Flow of XM-74 Grenade Discs.

Sintering

The delubed discs are placed on trays and inserted into the sintering furnace on a continuous push feed. The furnace used is a 6 zone Hayes Sintering Furnace. The cycle time through this furnace is 2 trays per hour that yields 16 pieces per hour. Total sintering time is 24 hours. The mid zone furnace temperature is maintained at 2600° to 2700°F. An inert atmosphere of disassociated ammonia was used at a flow rate of 500 cubic feet to 700 cubic feet per hour.

Heat Treatment

Equipment used for heat treatment is a Sunbeam Furnace, Model H. G. 91524 and a 38 inch x 24 inch x 16.5 inch deep quench tank.

The furnace is maintained at between 1700°F to 2000°F temperature. A nitrogen atmosphere is used in this furnace. After a specified time, the discs are removed and water quenched.

Machining

The discs are machined in a turret lathe. The disc is inserted between head and tailstock by applying pressure through an air cylinder attached to the tailstock. The diameter and the collar are machined in one setup.

IV. TELEDYNE FIRTH STERLING PROCESS DESCRIPTION

Granulation

Waxed powder is isostatically pressed at approximately 500B., however, our pressure gauges may not be accurate in this range. After isostatically pressing, the pressed material is placed in a Stokes Granulator and granulated with a .06 cm opening screen.

Granulated material sizing was accomplished with two Russell Finex Screeners Model 804/4. Course material was screened out with 24 mesh stainless steel wire cloth. Fine material was screened out with 54 mesh stainless steel cloth. The desired material for further processing is -24 mesh +54 mesh. Material is now ready for hydraulic pressing.

Compacting Equipment & Procedure

Equipment used for pressing this quantity of parts was a 200 ton M&M Model 2724 Double-Action Hydraulic Press with semi-automatic pressing capability and hopper and shoe loading capability. The mold was mounted

in a guided carrier attached to the movable lower ram to allow stripping and loading over the stationary lower ram. The bottom punch used is a plane flat faced cylindrical section, top punch imprinted with the required form.

Equipment recommended would be of 150 ton minimum capacity, double-action, guided ram vertical type with a minimum of 12" daylight.

Press-loading technique was to weigh the granulated powder (225-245 gm) on a Shadowgraph scale; powder was then transferred to the mold and leveled with a "T" bar leveler.

Significant time (approximately 3-4 minutes) was taken on the leveling operation. Uneven powder leveling at this step causes non-uniform thickness, varied diameters and, in extreme cases, shrinkage cracks.

Pressing speed used was approximately 10" per minute with rapid approach at approximately 50"/min. Dwell time of approximately 30 seconds at full pressure was used.

Pressing pressure should be in the range of 75 to 150 ton, as determined by particle size, distribution, die design, shrink factor and granual condition. Parts were successfully manufactured throughout the range of 60 through 130 tons, with L.S.F. in the range of 0.80 to 0.84.

Improved loading and leveling techniques shall be implemented to increase productivity and/or reduce scrap if sufficient parts are required to warrent fabrication of such devices not applicable to the quantity of parts manufactured to date.

Production rate, allowing for weighing, leveling, measurement and handling was approximately 12 pieces/hour. It is our considered opinion that this rate can be greatly improved.

Delubrication Procedure and Equipment

Dewaxing/delubricating equipment is a batch type furnace of the Wickman-Wimet design under license to the U.S. Government. This unit is a hydrogen atmosphere furnace with nitrogen purging capabilities. Working area is approximately .356 meters in diameter and .273 meters in height.

Parts are placed on alumina tiles shielded with alumina bubble that has been sized with -24 mesh +54 mesh stainless steel wire cloth. Tile, with

parts, are placed in dewax unit and stacked so as to input 24 parts per run. This number per run can be greatly increased with design techniques presently under consideration. Since this is a batch operation, no stoking rates apply.

After material has been loaded into the furnace, the lid is put in place and clamped. A nitrogen purge is initiated with a flow rate of 3500 LPH. This purge is held for 15 minutes then hydrogen is introduced at 2000 LPH and nitrogen is stopped. A "pop" test is performed to determine when the furnace atmosphere is correct, after approximately 15 minutes more of hydrogen flow. The furnace exhaust pipe is then lit to burn off the escaping hydrogen. Electrical power is then applied to the molybdenum wire wound element surrounding the work area. Within eight hours a temperature of 950°C is to be obtained and held for one hour, after which time electrical power is disconnected. A minimum cooling time of twelve hours is allowed. At the end of the twelve hour minimum cooling time, a nitrogen purge is initiated at a flow rate of 3500 LPH. The hydrogen is discontinued at this time also. When the exhaust flame is completely extinquished all gases are shut off and the lid can be removed and the parts taken out. Parts are now ready for first sinter.

At present, vertical furnace modifications and/or stoking furnace capabilities are under consideration to greatly increase present facility capabilities, and will be pursued if larger quantities warrant the expenditures.

First Sinter

First Sinter equipment is a batch type furnace of the Wickman-Wimet design under license to the U. S. Government. This unit is a hydrogen atmosphere furnace with nitrogen purging capabilities. Working area is approximately .356 meters in diameter and .273 meters in height.

Parts are placed on alumina tiles shielded with alumina bubble that has been sized with -24 mesh +54 mesh stainless steel wire cloth. Tile, with parts, are placed in sinter unit and stacked so as to input 12 parts per run. This number per run can be greatly increased with design techniques presently under consideration. Since this is a batch operation, no stoking rates apply.

After material has been loaded into the furnace, the lid is put in place and clamped. Anitrogen purge is initiated with a flow rate of 3500 LPH. This purge is held for 15 minutes, then hydrogen is introduced at 2000 LPH and nitrogen is stopped. A "pop" test is performed to determine when the furance atmosphere is correct after approximately 15 minutes

more of hydrogen flow. The furnace exhaust pipe is then lit to burn off the excaping hydrogen. Electrical power is then applied to the molybdenum wire wound element surrounding the work area. Within eighteen hours a temperature of 1324°C is to be obtained and held for four hours, after which time electrical power is disconnected. A minimum cooling time of twenty-four hours is allowed. At the end of the twenty-four hour minimum cooling time, a nitrogen purge is initiated at a flow rate of 3500 LPH. The hydrogen is discontinued at this time also. When the exhaust flame is completely extinquished, all gases are shut off and the lid can be removed and the parts taken out. Parts are now ready for second sinter.

At present, vertical furnace modifications and/or stoking furnace capabilities are under consideration to greatly increase present facility capabilities, and will be pursued if larger quantities warrant the expenditures.

Final sintering was accomplished in a double three zone, moly wound, D muffle, hydrogen atmosphere sintering furnace of Teledyne proprietary design, drawing C903-18. Approximate over-all length of this furnace is 8 meters. The hydrogen flow supplied directly to the exit end of the furnace tube is 250 $\pm$50 LPH.

Parts were sintered in molybdenum boats 18" long, 6" wide and 1" deep. Primary support used was 90 grit alumina, with a secondary coating of Norton E 111 alumina to prevent loss of surface finish as occurs with contact of course alumina.

Boat loading successfully used for those parts ranged from 1 to 6 pieces. The stoking rate used was approximately 1.5 rd/day. Target furnace temperatures, as measured by optical pyrometer on the bulbs, 1300, 1400, 1400, on the front, middle, and rear zones respectively. Because of the boat loading technique described above, actual part temperatures could not be recorded.

The thru-put capacity of this furnace is estimated to be 384 pcs/day.

Post Sinter Heat-Treating (Optional Technique)

Vacuum annealing is not required to achieve the low physical properties specified for this item; however, we elected to do so because the end item is greatly affected at a minimal cost.

Vacuum annealing was accomplished in a Teledyne proprietary design vacuum furnace. Working area approximately .406 meters in diameter by .508 meters high. A vacuum of 25 microns was used. A Stokes mechanical pump model number 212H-11 was used to achieve this vacuum.

Parts were placed in a crucible along with either alumina bubble or alumina sand. Total of 100 parts per run were annealed. A typical cycle consists of loading crucible into furnace, replacing lid and sealing furnace, and pumping down to 25 microns before adding power to the molybdenum heating element. After 25 microns have been reached, power was applied and a temperature of 1050°C was obtained within six hours. This temperature was held for eight hours and power was disconnected at the end of the eight hour period. A minimum cooling time of twenty-four hours is needed before allowing the vacuum pump to be turned off and atmosphere to be introduced into the working area. When atmosphere pressure has been reached, the furnace can be opened and the crucible removed.

V. VOUGHT CORPORATION PROCESS DESCRIPTION

The processing of the tungsten hemipsheres is shown in figure 4. The quality assurance inspection plan is shown in the appendix.

Teledyne Firth Sterlings hardware was ready for first article inspection on March 20, 1979. This inspection on 32 parts was completed at the Firth Sterling plant. The dye penetrant inspection showed what appeared to be surface porosity on the unscored side of the "as sintered" disc. It was decided to polish the surface and re-inspect it. After polishing, no apparent porosity "showed up" on the surface and it was proven that the "as sintered" surface, due to its fairly rough grain, traps the penetrant and appears to look porous when in reality there was no porosity extending into the material. No further polishing was done on the remaining parts that were processed.

All of the Firth Sterling discs were formed at a die stroke of 1.84 inch deep which was 0.12 inch deeper than the design stroke. The 1.84 inch stroke was set to "smooth out" the edge wrinkle experienced in the high ductility material. This deeper die stroke was responsible for edge cracking. It should also be noted that the Firth Sterling discs exhibited fragment wash out at the extreme edge of the parts, i.e., whole or partial fragments were missing. In pressing these parts a wrinkle occurred at each missing fragment location. This problem was later solved by Firth Sterling but did require a deeper die stroke in the first form.

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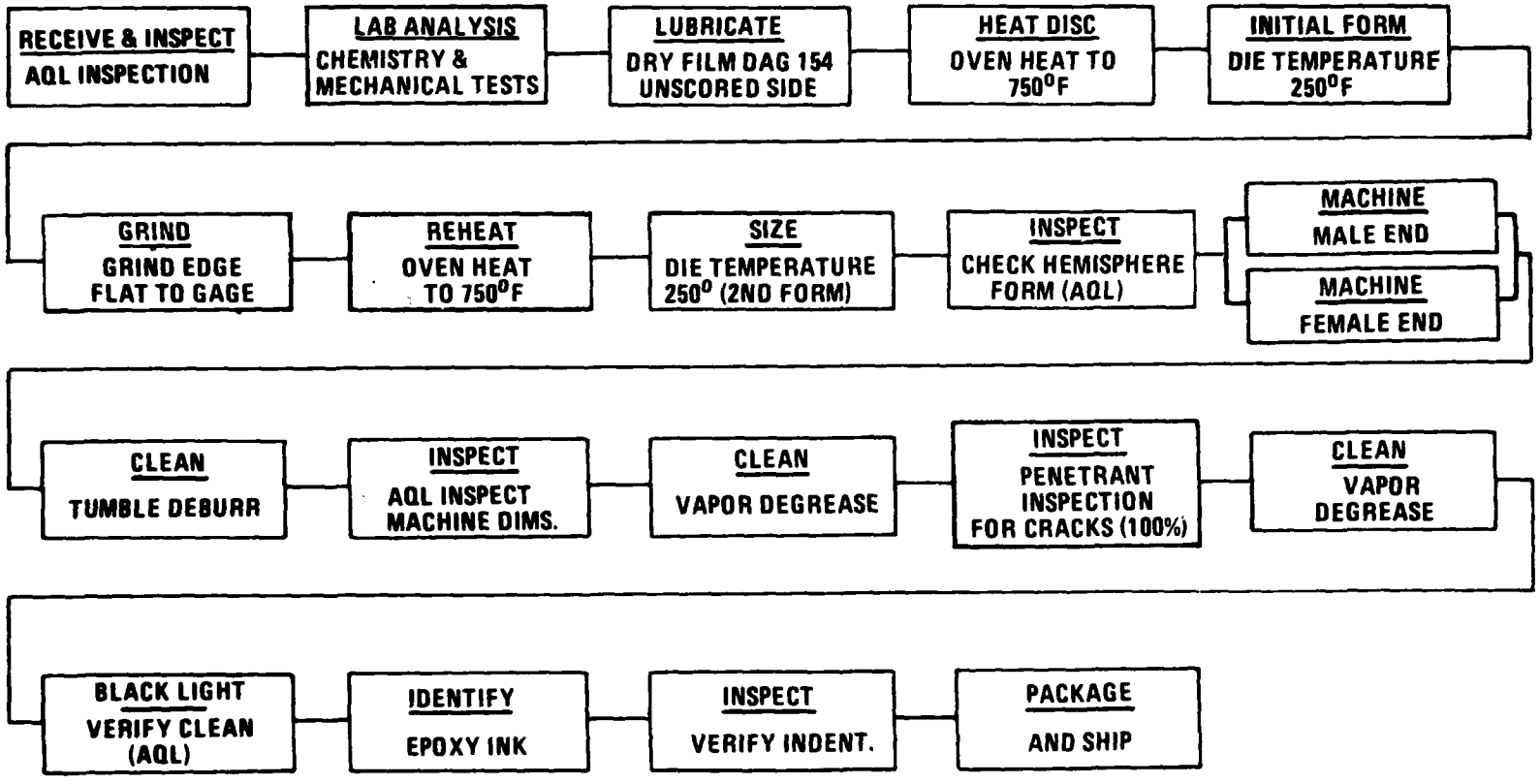


Figure 4. Process Diagram for Tungsten Hemisphere

Kennametals 10 piece first article hardware was received in June, 1979 and rejected based on two dimensional discrepancies and low ductility. After approval by ARRADCOM, the 10 discs were formed and machined. Dye penetrant inspection of the 10 hemispheres disclosed edge cracks in 3 parts. This cracking was attributed to forming the parts at a 1.84 inch die stroke instead of the 1.72 inch design stroke. In November, 95 parts were formed at the design stroke of 1.72 inches and showed a marked improvement. Five of the hemispheres were scrapped due to cracks.

Receiving and Inspection

The tungsten discs were inspected per MIL-STD 105. The sample size is 100% dimensionally inspected from each shipment. One disc from each suppliers lot is sectioned for chemistry and tensile test data. The tensile test bar is cut from the center of the disc and pulled at the rate shown in specification 707-111. Each disc is also visually inspected for scratches, gouges, missing fragments, etc. Upon completion, the shipment is released to the forming presses.

Forming

Prior to forming, the smooth sides of the discs are lubricated with a dry film DAG 154 lubricant and allowed to dry. They are then loaded on trays and placed in a Lindberg furnace that is maintained at $750^{o}F \pm 25^{o}F$ and soaked for 30 minutes. Each disc is removed and placed into the first form die and formed. The design die stroke is 1.72 inches. The Lindberg furnace is capable of heating 100 discs/cycle.

The first form is done on a 220 ton Niagara mechanical press with a 12 inch (max) stroke and a capability of 20 strokes per minute. The forming die is lubricated every 4 or 5 parts with a standard red forming oil. After first form the hemipshere form is 90% complete. The edges of the hemisphere are ground flat prior to the second forming operation. Each part is ground to a gage to assure uniformity in the coining operation. The parts are re-heated to $750^{o}F$ prior to the second forming for 30 minutes. The second form is accomplished on a 70 ton Ferracute press capable of 45 strokes per minute. The forming dies in each press are pre-heated using a 6 inch diameter band heater to $250^{o}F$. The coining die stroke is set by trail to obtain the full form on the 1.157 inch radius.

After forming, the hemispheres are visually inspected for cracks. The 1.157 inch radius is checked on a 20X shadowgraph (optical comparator) to verify the form. A sample size of 5 out of every 50 parts are checked on the shadowgraph.

Machining

The hemispheres are loaded into a hemispherical lathe fixture and held in place with a pneumatically operated male plunger. Pressure is continuous throughout the machining. The lathe is a Warner-Swasey turret lathe. The tooling cutters are set up to produce either a male part or a female part, i.e. the lathe cutter set up must be changed for each configuration. Machining time is approximately 4-5 minutes per part. The machined dimensions are checked on each part prior to moving to the next station. Ring gages are used for the diameters and a height gage (with dial indicator) is used for the radius height.

Vibratory Deburr

The hemispheres are vibratory deburred for at least 30 minutes in an alkaline solution.

Inspect (AQL 4.0)

Inspection at this station is done per MIL STD 105 whereby an AGL sample size is taken and inspected 100% to all applicable print dimensions.

Vapor Degrease

The residue from tumble deburring and handling are cleaned at this station prior to the dye penetrant process.

Penetrant Inspect (100%)

The hemipsheres are penetrant inspected per MIL-I-6866. No cracks are permitted on the outside surface. Other anomalies including porosity are not cause for rejection.

Vapor Degrease and Ultra Violet Light (AQL 4.0)

The finished parts are vapor degreased to remove all traces of residual penetrant and visual checked using the ultra violet light.

Inspect and Identify

The part number and lot number is applied on the O.D. surface using black epoxy ink per MIL-E-43553.

VI. CONCLUSIONS

The original program was geared to form the discs both mechanically and hydraulically. Only the mechanical forming was attempted because of speed of operation and ease of forming. It was found that material ductility in the range of 18% to 25% provided the most successful (no surface cracks) hemispheres. Stroke depth and die forming radius was also very critical in forming hemispheres with no edge wrinkles. Edge wrinkles almost always lead to vertical edge cracks.

The hardware provided by Teledyne Firth Sterling was considered higher in overall quality than Kennametal (surface finish, uniformity, fragment definition and dimensional consistency). The Firth Sterling hardware was formed at a die stroke that was set too deep for consistent success. The setting was changed from 1.84 to 1.72 on a follow-on effort that resulted in a scrap rate less than 2%.

For follow on programs, it is recommended not to require heat treatment or annealing to obtain high ductilities. It is within the state-of-the-art to obtain 18% to 22% ductility with an "as sintered" part.

In summary, the following criteria should be used:

- die stroke - 1.72 inches or less, depending on forming radius
- form radius - 1.0 inch radius minimum
- form temperature - 650°F - 750°F provided best results (depends also on hardware formulation)
- die temperature - 250°F was design temperature - cold dies were never used
- lubrication - DAG 154 (moly-disulfide) on smooth side of discs worked best
- cleaning - tumble de burr in shaker works best - zyglo powder residue still provides problems

APPENDIX A

1.0 SCOPE

1.1 This Quality Assurance Inspection Plan outlines the program for the inspection of prescored tungsten alloy hemispheres to the requirements set forth in the applicable drawings and specifications.

2.0 REFERENCED DOCUMENTS

2.1 Government

MIL-C-45662A	"Calibration System Requirements"
MIL-I-6866	"Inspection, Penetrant Method of"
MIL-I-45208	"Inspection System Requirements"
MIL-STD-105D	"Sampling Procedures and Tables for Inspection by Attributes"
DI-R-1724	"Quality Inspection Test, Demonstration and Evaluation Report"
DI-R-1725A	"Quality Inspection Report of Deficiencies Found in Material"
Dwg 9313567	"Tungsten, Disc"
Dwg T9298784	"Hemisphere, Female"
Dwg T9298785	"Hemisphere, Male"
Dwg 9313626	"Tungsten Powder Alloy"

2.2 Michigan Plant

QCM	"Quality Control Manual"
QCI 4-4.1	"Penetrant Inspection"
QCP 746.2	"Procurement Documentation"
QCP 747.18	"Shipping Inspection; General"
QCP 747.19	"Receiving Inspection; General"
QCP 747.28	"Final Inspection; General"
QCP 747.36	"Measuring and Test Equipment Repair and Calibration - Metrology Laboratory"
QCP 747.41	"Use of Quality Control Tags and Line Stop Alert Forms"
Form No. 7-43590	"Discrepancy Record Information Only"
Appendix I	"Inspection Planning Schedules"
Appendix II	"Inspection Station and Flow Diagram"

3.0 QUALITY SYSTEM

3.1 The Quality System is described in the Michigan Plant Quality Control Manual composed of Quality Control Procedures and Quality Control Instructions. These documents conform to the provisions of MIL-I-45208.

3.2 Calibration of instruments, tools, and gages used for acceptance of the hemispheres shall be in conformance with the requirements of QCP 747.36 (reference MIL-C-45662A).

3.3 Nonconforming hardware will be identified and controlled to eliminate the possibility of intermingling with acceptable hardware. These items will be tagged using the "Quality Control tag" in accordance with QCP 747.41. Discrepancies will be reported on form number 7-43590, "Discrepancy Record Information Only." Each discrepancy will be dispositioned by Engineering and Quality Engineering personnel assigned to the hemisphere program. Discrepancies written against major characteristics will be reported to the customer by Quality Engineering. Dispositions will consist of "Acceptable As Is," "Rework to B/P," or "Scrap."

3.4 Government-furnished property is not applicable to this contract; therefore, DI-R-1725A will not be used.

4.0 PROCUREMENT AND SUPPLIER CONTROL

4.1 Quality Engineering personnel will review and approve purchase requisitions and purchase orders, and will assign and maintain the Quality Requirement Codes to be placed on the purchasing documentation (reference QCP 746.2).

4.2 Suppliers of the tungsten base, high density metal are required to conform to the requirements of Specification 707-111.

5.0 SAMPLING AND CLASSIFICATION OF CHARACTERISTICS

5.1 Each drawing characteristic will be sample inspected to MIL-STD-105D, General Inspection Level II. The AQL to be used is dependent upon the characteristic classification.

Classification	AQL
Major	1.0
Minor	4.0

5.2 Three drawing characteristics on each of the hemisphere subassembly drawings have been classified as major.

Characteristics	Drawing Numbers
⌖ | A Ⓜ | ⌀.006 Ⓜ	T9298784 & T9298785
1.157 $^{+.000}_{-.005}$ Spherical Radius	T9298784 & T9298785
No surface cracks on outside surface	T9298784 & T9298785

The remaining drawing characteristics have been classified as minor.

6.0 INCOMING INSPECTION

6.1 Receiving inspection of the pre-sintered scored tungsten disc, P/N 9313567, will be conducted in accordance with the requirements of Inspection Planning Schedule (see Appendix I) and QCP 747.19. Sampling inspection will be performed to a 1.5 AQL.

6.2 Material properties will be checked on an as needed basis to control vendor supplied material.

7.0 IN-PROCESS INSPECTION

7.1 Normal first piece inspection, plus timely in-process inspections, will be performed on parts after forming operations. These inspections will be conducted in accordance with the requirements of Inspection Planning Schedules (see Appendix I).

8.0 FINAL INSPECTION

8.1 Final inspection will be conducted, after machining operations have been completed, in accordance with the requirements of Inspection Planning Schedules (see Appendix I) and QCP 747.28.

9.0 NONDESTRUCTIVE TESTING

9.1 Penetrant inspection will be performed on each hemisphere, after final dimensional inspection operations, in accordance with Inspection Planning Schedule (see Appendix I) and QCI 4-4.1 (reference MIL-I-6866).

10.0 INSPECTION TOOLING

10.1 Each drawing characteristic will be inspected utilizing the equipment (or alternate that is equivalent) as specified on the applicable Inspection Planning Schedule.

11.0 SHIPPING INSPECTION

11.1 Packing and packaging will be inspected to the requirements of QCP 747.18 to ensure that the hemispheres are packed for shipment in accordance with the best commercial practices for safe transportation.

12.0 TRACEABILITY

12.1 Identification to provide traceability of material lot or batch numbers will be maintained during the receiving operations, and will become an integral part of the control system throughout fabrication. This requirement will be controlled by the use of Manufacturing and Inspection planning.

13.0 MICHIGAN PLANT CERTIFICATION

13.1 Quality Engineering will provide the Certificate of Compliance with each lot shipment of hemispheres to Picatinny Arsenal, in accordance with the requirements of DI-R-1724.

Copies of the material certification received from the tungsten supplier will also be sent with each shipment.

PLANNING INSTRUCTION RECORD

TRACEABILITY REQ'D: [X] YES [ ] NO | LOGBOOK REQ'D: [ ] YES [X] NO | PART NO.: 9313567-510

DATA

PART DESCRIPTION: TUNGSTEN, DISC (SCORED) | SOURCE: B | USABLE FOR SPARES: [ ] YES [X] NO | REPLACES PART NO.: —

MATERIAL DESCRIPTION: TUNGSTEN BASE, HIGH DENSITY, METAL DISCS | MATERIAL CODE: | REPLACED BY PART NO.: —

CUTTING SIZE: ~ | PART SIZE: 3.625 DIA X .100TH CK | RUN WITH PART NOS.: —

EFFECTIVITY RECORD

MODEL	END ITEM DESCRIPTION	E/I	PAPER EFFECTIVITY	ITEM	IND	E/C	NEXT ASSEMBLY WHERE USED	QTY/NA	QTY/EI
XM-74	HEMISPHERE, FEMALE	FH	1-150	~	1	—	9298784	1	1
XM-74	HEMISPHERE, MALE	MH	1-150	~	1	—	9298785	1	1

CHANGE RECORD

CHANGE AUTHORITY	REVISION LETTERS IPS	PA	DWG	PLNG	RCD CHG	PAGE NUMBERS CHANGED	CHANGE INSTRUCTIONS	CHANGE DATE	CHANGE APPROVAL PE	QA	TS	WC
E.O. B5000.5	0	-	A	0			ORIGINAL RELEASE	1-10-79	[illegible]	[illegible]		ML

(EK 101 03)

PLNG. REV.: 0 | TYPE OF REVISION: [ ] OPTIONAL [X] MANDATORY | CHECKER: [illegible] | DATE CHECKED: 1-19-79 1-10-79 | PLANNER: E. W. [illegible] | NO. OF PLNG PAGES: 1 | NO. OF RECORD SHEETS: 1

(EK 201 03)

WORK ORDER

W.O. NO.	MODEL	SPCSAR	M-DAY COMP / REL	DELIVER COMPL HARDWARE TO	STRT OPR	TOTAL QTY	ID	ORIGINAL W.O.
				~			14	

CHARGE NO.	QUANTITY	CHARGE NO.	QUANTITY	AUTHORITY REFERENCE

7-84582 NOV 77

OPERATION INSTRUCTIONS

PART NUMBER 9313567-510

OPER. NO.	LOAD GROUP	SET-UP	STANDARD HOURS	OPERATION DESCRIPTION	AQL	TOOLING
				PURCHASE PARTS:		
				PURCHASE TUNGSTEN SCORED DISCS		
				PER DWG. 9313567 "REV. A"		
				ONLY FROM —		
				TELEDYNE FIRTH STERLING		
				#1 TELEDYNE PLACE		
				LA VERGNE, TENN. 37086		
				VENDOR TO I.D. PARTS AS -510		
				NOTE: -510 P/N GENERATED TO		
				DISTINGUISH VENDORS		
				P.O. REQUIREMENT -		
				MATERIAL LOT TRACEABILITY		
				MATERIAL REQUIREMENT —		
				MATERIAL CERTIFICATION PER		
				MTL SPEC. 707-111		
10	FR	—	.0167	RECEIVE		
20	ISR	—	—	RECEIVING INSPECT	AQL 100% 1.5	
				— PER IPS		
30	FR	—	.0333	DELIVER TO MAIN STORES		
				F/S		

CHANGE INSTRUCTIONS

DATE OF CHANGE 1-10-79

REVISION 0

PAGE NO. 1

7-54525 JAN 74

INSPECTION PLANNING SCHEDULE

PART NAME TUNGSTEN DISC (SCORED)			REC. INSPECTION ☒
PART NUMBER 9313567-510	DWG. NO. 9313567	REV. A	IN PROCESS INSP
I.P.S. NUMBER ~	I.P.S. REV. 0		FINAL INSPEC.
ENGINEERING ORDER			VENDOR
W/O NO.	S/N	LOT NO.	RATING

SPECIAL INSTRUCTIONS	CONFIG	LOT SIZE
1) VENDOR CERTIFICATION OF COMPLIANCE REQ.(2) LOT TRACEABILITY REQ.(3) SEE I.P.S FOR DIMENSION LOCATION.	XM-74	

NO	CHARACTERISTIC	AQL	EQUIPMENT	SAMPLE SIZE	NO REJECT	REMARKS
20	VERIFY THE FOLLOWING:					
1.	COMPLIANCE TO ALL REQUIREMENTS OF B/P 9313567 REV"A".		VISUAL & VENDOR CERT.			
2.	MATERIAL CERTIFICATION PER MTL SPEC 707-111		VISUAL & VENDOR CERT.			
3.	NO DAMAGE TO PART	1.5	VISUAL			
4.	PART IDENT AS -510, INK STAMP UNSCORED SIDE	1.5	VISUAL			
5.	FIRST ARTICLE INSPECT MATERIAL LOT PER MTL SPEC 707-111	100% INSP	QC MATERIAL LAB.			
6.	INSPECT UNSCORED SIDE FOR OPEN VOIDS, VOID SIDE SHALL NOT EXCEED .020 INCH.	100% INSP	VISUAL & SCALE.			

REQUIREMENTS	SPECIFICATION	CERT REQ'D	VENDOR	LTV	REQUIREMENTS	SPECIFICATION	CERT REQ'D	VENDOR	LTV
IDENTIFICATION					SERIALIZE				
SURFACE TREATMENT					MAGNETIC PARTICLE				
PENETRANT INSP					RADIOGRAPHIC				
MACHINE					METALGRAPHIC				
FUNCTIONAL					ULTRASONIC				
CLEAN					PACKAGE				

PREPARED BY	APPROVED BY	DATE	INSPECTOR	DATE
[signature]	[signature]	1-18-79		

7-40808 FEB 73

INSPECTION PLANNING SCHEDULE (Continuation Sheet)

PAGE 2 OF 4

PART NAME: TUNGSTEN DISC (SCORED)			RECEIVING INSPECTION: X
PART NO.: 9313567-510	DWG. NO.: 9313567	REV.: A	IN-PROCESS INSPECTION:
I.P.S. NO.: ~	I.P.S. REV.: O		FINAL INSPECTION:

NO.	CHARACTERISTIC	AQL	EQUIPMENT	SAMPLE SIZE	NO. REJECT	REMARKS
7	PENETRANT INSPECT PER MIL-I-6866 TYPE I, METHOD A. COMPARE TO STANDARD FOR ACCEPTANCE. (MTL SPEC 707-111) NOTE: INSPECT UNSCORED SURFACE ONLY.	100%	QC MATERIAL LAB			
8.	$3.625^{+.000}_{-.005}$ Ø	1.5	MICROMETER			
9.	$3.34^{+.03}_{-.03}$ DIA	1.5	MICROMETER			
10.	0.139 ± .003 TYP DIM (BETWEEN SCORES)	1.5	OPTICAL COMPARATOR			
11.	STRAIGHT WITHIN .05 (SEE NOTE 3)	1.5	STRAIGHT EDGE & SCALE			
12.	STRAIGHT WITHIN .03 (SEE NOTE 3)	1.5	STRAIGHT EDGE & SCALE			
13.	0.072 ± .010 DIM (SEE NOTE 6)	1.5	POINT MICROMETER			
14	$0.072^{+.000}_{-.007}$ DIM (SEE NOTE 5)	1.5	POINT MICROMETER			
15.	64 FINISH	1.5	VISUAL COMPARATOR			
16	50° +5° TYP	1.5	OPTICAL COMPARATOR OR PROTRACTOR			
17	80° +5° TYP	1.5	OPTICAL COMPARATOR OR PROTRACTOR			
18.	.015R MAX TYP (SEE NOTE 5)	1.5	OPTICAL COMPARATOR OR RADIUS GAUGE			

PREPARED BY: [signature] APPROVED BY: W Parker DATE: 1-18-79 INSPECTOR: DATE:

7-40810 JAN 73

INSPECTION PLANNING SCHEDULE (Continuation Sheet)

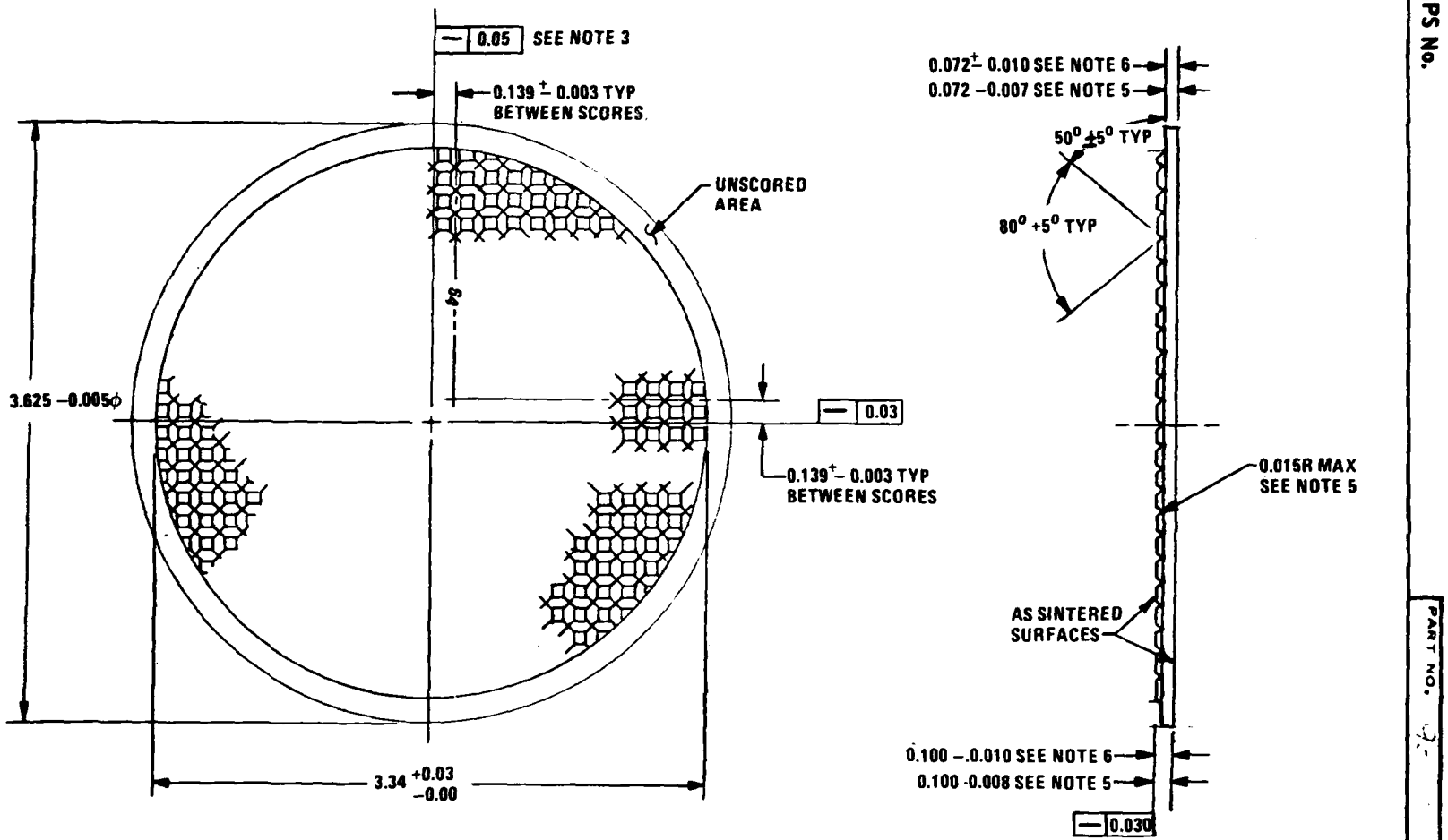
PAGE 3 OF 4

PART NAME: TUNGSTEN DISC (SCORED)			RECEIVING INSPECTION: X
PART NO.: 9313567-510	DWG. NO.: 9313567	REV.: A	IN-PROCESS INSPECTION:
I.P.S. NO.: ~	I.P.S. REV.: 0		FINAL INSPECTION:

NO.	CHARACTERISTIC	AQL.	EQUIPMENT	SAMPLE SIZE	NO. REJECT	REMARKS
19.	$0.100^{+.018}_{+.000}$ DIM (SEE NOTE 6)	1.5	MICROMETER			
20.	$0.100^{+.008}_{+.000}$ DIM (SEE NOTE 5)	1.5	MICROMETER			
21.	STRIGHT WITHIN 0.03	1.5	OPTICAL COMPARATOR OR STRAIGHT E FEELER GAUGE			

PREPARED BY: L Thorson — APPROVED BY: [illegible] — DATE: 1-18-79 — INSPECTOR — DATE

7-40810 JAN 73



NOTES:
1. SPEC MIL A 2550 AND ANSI Y14.5–1973 APPLY
2. MATERIAL: TUNGSTEN POWDER ALLOY PER SPEC 707–111.
3. SCORINING LOCATION OPTIONAL.
4. PENETRANT INSPECT PER MIL-1-6866 TYPE 1, METHOD A. COMPARE TO "STANDARD" FOR ACCEPTANCE. (REF: SPEC 707–111)
5. APPLIES TO 75% OF DISC AREA.
6. APPLIES TO 25% OF DISC AREA.
7. IDENTIFY PER SPEC 707–111.

REV. C | ILLUS. --- | DATE 11/7/80 | PAGE 4 OF 4 | ILLUS. NO. 1

7-80811 JAN 78

IPS No.

INSPECTION PLANNING ILLUSTRATION

PART NO. 4-

INSPECTION PLANNING SCHEDULE

PART NAME HEMISPHERE, MALE			REC. INSPECTION
PART NUMBER 9298785	DWG. NO. 9298785	REV. O	IN PROCESS INSP X
I.P.S. NUMBER ~	I.P.S. REV. C		FINAL INSPEC. X
ENGINEERING ORDER			VENDOR
EO. 85000.6			
W/O NO.	S/N	LOT NO.	RATING

SPECIAL INSTRUCTIONS	CONFIG	LOT SIZE
1) LOT TRACEABILITY REQUIRED. (2) SEE ILLUS FOR DIM & LOCATIONS. 3) GOVERNMENT INSPECTION VERIFICATION REQUIRED.	PM	~

NO	CHARACTERISTIC	AQL	EQUIPMENT	SAMPLE SIZE	NO REJECT	REMARKS
35	VERIFY VIBRATORY DEBURR AND PART CLEANLINESS.	4.0	VISUAL			
A	2.220 $^{+.000}_{-.010}$ DIA	4.0	GO/NO GO RING GAUGE			
B	0.010 $^{+.010}_{-.005}$ RADIUS OR 0.010 $^{+.010}_{-.005}$ X 45° CHAMFER	4.0	RADIUS GAUGE OR SCALE & PROTRACTOR			
45	1.157 $^{+.000}_{-.005}$ DIM	1.0	HEIGHT GAUGE & SURFACE PLATE			
A	0.04 $^{0}_{-.00?}$ DIM	1.0	DEPTH MICROMETER OR DIAL INDICATOR.			
B	— 0.004 DIM	1.0	FEELER & SURFACE PLATE.			
C	2.22 Ⓜ TO "A" (M) .006 (A)	1.0	OPTICAL COMPARATOR OR DEPTH MICROMETER			

REQUIREMENTS	SPECIFICATION	CERT REQ'D	VENDOR	LTV	REQUIREMENTS	SPECIFICATION	CERT REQ'D	VENDOR	LTV
IDENTIFICATION					SERIALIZE				
SURFACE TREATMENT					MAGNETIC PARTICLE				
PENETRANT INSP					RADIOGRAPHIC				
MACHINE					METALGRAPHIC				
FUNCTIONAL					ULTRASONIC				
CLEAN					PACKAGE				

PREPARED BY B. Chenen — APPROVED BY B. Chenen — DATE A-11 1-3-80 — INSPECTOR — DATE

7-40508 FEB 73

INSPECTION PLANNING SCHEDULE (Continuation Sheet)

PAGE 2 OF 3

PART NAME: HEMISPHERE, MALE			RECEIVING INSPECTION:
PART NO.: 9298785	DWG. NO.: 9298785	REV.: 0	IN-PROCESS INSPECTION: X
I.P.S. NO.: ~	I.P.S. REV.: C		FINAL INSPECTION: X

NO.	CHARACTERISTIC	AQL	EQUIPMENT	SAMPLE SIZE	NO. REJECT	REMARKS
55	PENETRANT INSPECT PER MIL-I-6866, TYPE AND METHOD OPTIONAL. NO CRACKS PERMITTED ON OUTSIDE SURFACE. OTHER ANOMALIES INCLUDING POROSITY SHALL NOT BE CAUSE FOR REJECTION.	100%	VISUAL & ULTRA-VIOLET LIGHT.			
66	VERIFY REMOVAL OF RESIDUAL PENETRANT.	4.0	VISUAL & ULTRA-VIOLET LIGHT.			
75	INSPECT: VERIFY PART & LOT NUMBER ON O.D SURFACE ADJACENT TO MACHINE EDGE. USING BLACK EPOXY INK PER MIL-E-43553 AND MPS 50-55-07. SEE ILLUS	4.0	VISUAL			

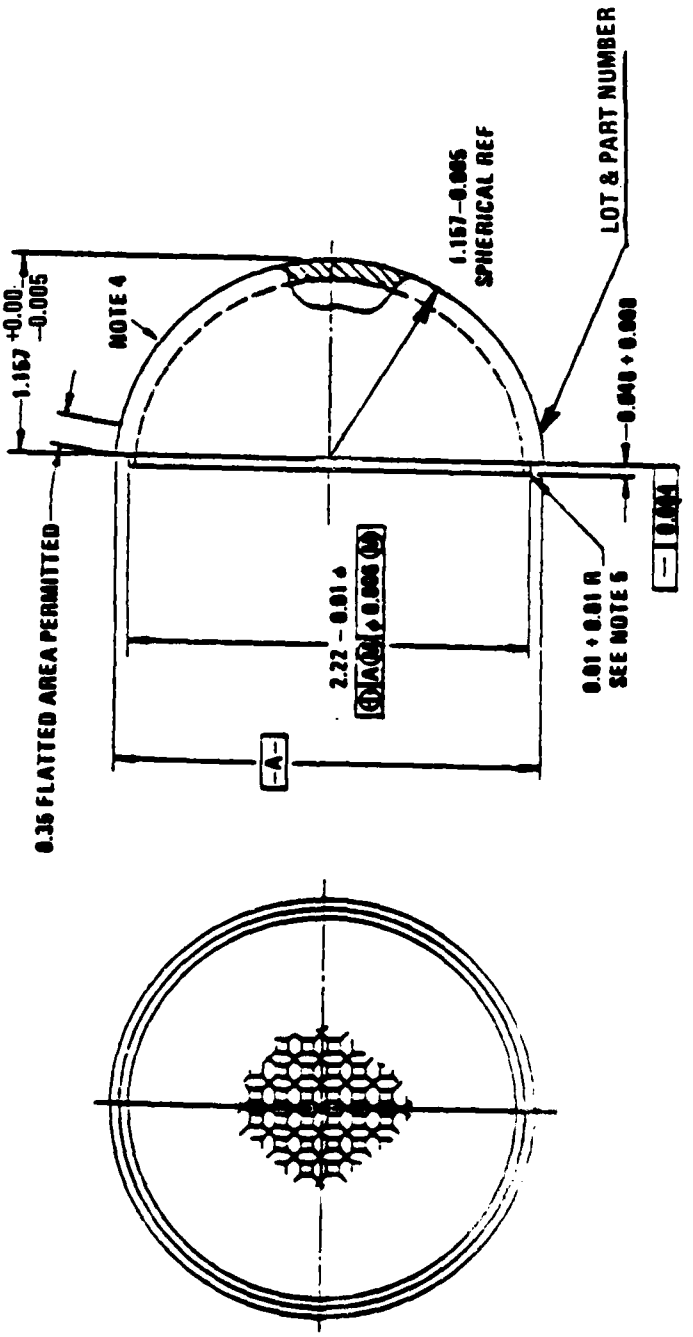
PREPARED BY: W Chesser — APPROVED BY: W Chesser A-12 — DATE: 1-3-80 — INSPECTOR — DATE

7-40810 JAN 79

INSPECTION PLANNING ILLUSTRATION

IPS No. ~

PART NO. 9298785



A-13

REV. C	ILLUS. NHP	DATE 7-8-80	PAGE 3 OF 3	ILLUS. NO. 1

7-60811 JAN 73

INSPECTION PLANNING SCHEDULE

PART NAME HEMISPHERE, FEMALE			REC. INSPECTION
PART NUMBER 9298784	DWG. NO. 9298784	REV. O	IN PROCESS INSP X
I.P.S. NUMBER ~	I.P.S. REV. C		FINAL INSPEC. X
ENGINEERING ORDER			VENDOR
EO 85 009-6			
W/O NO.	S/N	LOT NO.	RATING

SPECIAL INSTRUCTIONS	CONFIG	LOT SIZE
1) LOT TRACEABILITY REQUIRED (2) SEE I.L.V.S FOR DIM'S & LOCATIONS.	PM	~
(3) GOVERNMENT INSPECTION VERIFICATION REQ'D.		

NO	CHARACTERISTIC	AQL	EQUIPMENT	SAMPLE SIZE	NO. REJECT	REMARKS
35	VERIFY THE FOLLOWING					
A.	VIBRATORY DEBURR AND PARTS ARE CLEAN	4.0	VISUAL			
B	2.224 $^{+.010}_{-.000}$ DIA	4.0	GO/NO GO PLUG GAUGES.			
C	0.067 $^{+.005}_{-.000}$ DIM	4.0	DEPTH MICROMETER OR DIAL INDICATOR & STAND.			
D	— .004	4.0	FEELER & SURFACE PLATE			
E	0.010 $^{+.010}_{-.000}$ RADIUS OR 0.010 $^{+.010}_{-.000}$ X45° CHAMFER	4.0	RADIUS GAUGE OR SCALE & PROTRACTOR			
45	VERIFY THE FOLLOWING					
A	1.157 $^{+.000}_{-.005}$ DIM	1.0	HEIGHT GAUGE & SURFACE PLATE.			

REQUIREMENTS	SPECIFICATION	CERT REQ'D	VENDOR	LTV	REQUIREMENTS	SPECIFICATION	CERT REQ'D	VENDOR	LTV
IDENTIFICATION					SERIALIZE				
SURFACE TREATMENT					MAGNETIC PARTICLE				
PENETRANT INSP					RADIOGRAPHIC				
MACHINE					METALGRAPHIC				
FUNCTIONAL					ULTRASONIC				
CLEAN					PACKAGE				

PREPARED BY [signature] APPROVED BY [signature] DATE A-14 1/3/86 INSPECTOR DATE

7-40606 FEB 79

INSPECTION PLANNING SCHEDULE (Continuation Sheet)

PART NAME: HEMISPHERE, FEMALE			RECEIVING INSPECTION:
PART NO.: 9298784	DWG. NO.: 9298784	REV.: 0	IN-PROCESS INSPECTION: X
I.P.S. NO.: ~	I.P.S. REV.: C		FINAL INSPECTION: X

NO.	CHARACTERISTIC	AQL	EQUIPMENT	SAMPLE SIZE	NO. REJECT	REMARKS
B	2.224 Ⓜ A(M) .006 (M)	1.0	CALIPER.			
C	2.314 +.000 -.010 DIA	1.0	O.D MICROMETER			
55	PENETRANT INSPECT PER MIL-I-6866 TYPE 1 METHOD OPTIONAL. NO CRACKS PERMITTED ON OUTER SURFACE. OTHER SURFACE ANOMALIES INCLUDING PORosity SHALL NOT BE CAUSE FOR REJECTION.	100%	VISUAL & ULTRA VIOLET LIGHT.			
65	VERIFY REMOVAL OF RESIDUAL PENETRANT	4.0	VISUAL & ULTRA VIOLET LIGHT.			
75	INSPECT: VERIFY PROPER PART & LOT NUMBER ON O.D SURFACE ADJACENT TO MACHINED EDGE (ILLUS #7) USING BLACK EPOXY INK PER MIL-E-43553 AND MPS 50-55-07.	4.0	VISUAL			

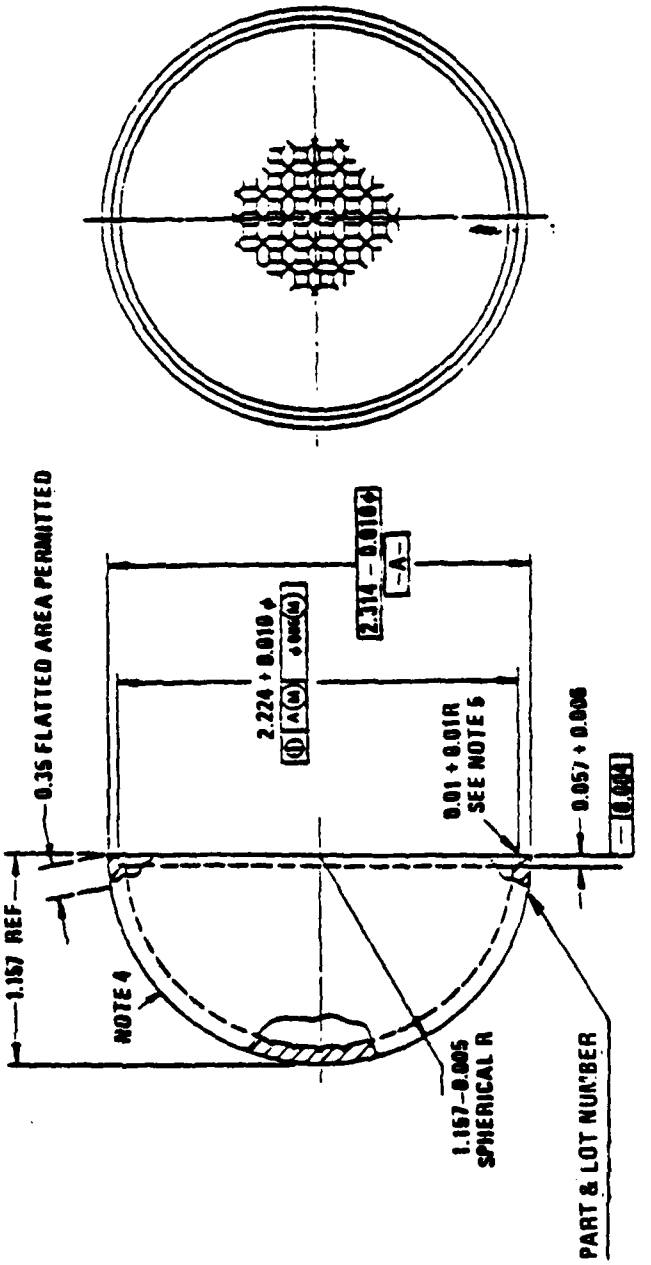
PREPARED BY: [signature] APPROVED BY: [signature] DATE: A-15 1/3/80 INSPECTOR: DATE:

7-40810 JAN 79

INSPECTION PLANNING ILLUSTRATION

IPS No. ~

PART NO. 9298784



REV. C	ILLUS. HHP	DATE 1/3/80	PAGE 3 OF 3	ILLUS. NO. 1

7-40811 JAN 73

ORIG. _____

WRITER _____

DISTRIBUTION _____

CODE IDENT NO. 17242

VOUGHT CORPORATION
michigan plant
38111 Van Dyke Avenue • Sterling Heights Michigan 48077
an LTV company
ENGINEERING DEPARTMENT SPECIFICATION

NO. 707-111

PAGE 1 OF 7

DATE 10 JAN 1979

RELEASE EO 85000.5

APPENDIX B

MATERIAL SPECIFICATION

FOR

TUNGSTEN BASE, HIGH DENSITY METAL DISCS

APPROVALS

ORIG. GROUP	PROJ. ENGR.				
DATE	DATE	DATE	DATE	DATE	DATE
	W. Mrdeza	1/5/79	Dick Mumford	R. Hardy	
			1/9/79	1-9-79	

1. SCOPE

1.1 This specification covers the materials and fabrication processes to produce tungsten base high density metal parts which are to be severely bent or drawn into hemispherical shape.

2. APPLICABLE DOCUMENTS

2.1 Government documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

STANDARDS

Federal

Fed. Test Method Std. No. 151	Metals; Test Methods

Military

MIL-1-6866	Inspection, Penetrant Method Of
MIL-STD-105	Sampling Procedures & Tables for Inspection by Attributes
MIL-A-2550	Ammunition, General Specification For
MIL-STD-129	Marking for Shipment and Storage

DRAWINGS

9313567	Disc, Tungsten

(Copies of specifications, standards, publications, and drawings required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM B-311	Density of Cemented Carbides
ASTM E-8	Tension Testing of Metallic Materials

(Application for copies of the above publications should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.)

3. RAW MATERIALS

3.1 Tungsten powder. The powder shall be hydrogen reduced tungsten powder produced by normal production methods.

3.2 Alloying Elements. Elemental powders for alloying shall be high purity.

3.3 Raw Material Inspection. A certificate of analysis for all powders showing compliance to the requirements herein shall be provided by the supplier for each material lot.

4. COMPOSITION OF MIX

Each mix composition shall be identified by a lot number and be in accordance with Table I. Alloy constituents shall be carefully weighed on scales which are accurate within 2 percent.

Table B-I. Mix Composition

Tungsten, % by weight	91 max
Nichel, % by weight	4.5 to 7.5
Iron, % by weight	2.5 to 5.5
Total other elements, % by weight	1.5 max - Specify type, grade and purity of each.

4.1 Mix control. Each mix of powder (which constitutes a lot) shall be subjected to tests before being released for production. The content for each mix shall be chemically analyzed to be in conformance with the requirements herein (see 7.7.6). Tungsten discs shall be prepared and at least two (2) test blanks conforming to ASTM E-8, Figure 6 , shall be prepared from completed discs. Tensile strength, density, and hardness shall be verified to conform

to requirements herein for each of the two test blanks. Failure to meet these requirements shall be cause for rejection of the entire mix. Rejected mixes may be completely analyzed to determine possibility of re-working. The re-worked mix may be resubmitted for the mix control tests.

5. COMPACTED DISC IDENTIFICATION

Identification shall provide record traceability to the raw material, the blended powder mix, and to the discs compacted during each lot production.

6. TUNGSTEN DISC REQUIREMENTS

6.1 First article. Unless otherwise specified in the purchase order, before production has commenced a sample or samples of the tungsten discs shall be made available to Vought Q. C. personnel or his authorized representative for approval in accordance with 7.4. The approval of the first article samples authorizes the commencement of production but does not relieve the supplier of responsibility for compliance with all applicable provisions of this specification.

6.2 Physical and Mechanical Properties. The discs shall have properties conforming to Table II, as determined using sub size test blank(s) from tungsten discs per ASTM E-8, Figure 6. In addition to test blank(s) from tungsten disc, five production parts out of 100 may also be tested for density, hardness, and porosity per the applicable Military Standards.

Table B–II. Physical and Mechanical Properties

Parameters	Value
Physical	
Density (g/cc)	17.0 min.
Hardness (Rockwell "C")	32 max.
Mechanical	
Ultimate tensile strength (psi)	100,000 min.
Elongation (percent) @ 0.02 in/min cross head speed	25.0 min.

6.3 Microstructure. The microstructure shall exhibit a uniform distribution of tungsten and binder material when viewed at 200 magnifications.

6.4 Dimensions. The dimensions shall be as specified on drawing 9313567 disc, tungsten. Material shall be pressed as one piece with no sinter brazing or other joining methods permitted.

6.5 Porosity. The maximum level of surface porosity shall not exceed that amount contained in the standard supplied by Vought when inspected per 7.7.7.

7. QUALITY ASSURANCE PROVISIONS FOR TUNGSTEN DISCS

7.1 Responsibility for Inspection. Unless otherwise specified in the purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the procuring activity. The procuring activity and/or Vought Corporation reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

7.2 Classification of Tests. The inspection and testing of the material shall be classified as follows:

a. First article inspection (7.4)
b. Quality conformance tests (7.5)

7.3 Lot. A lot shall be defined as a uniform blend of one mix of powder. If a shipment of items is made from more than one lot, each lot must be separately identified.

7.4 First Article Inspection

7.4.1 Sampling. When first article testing is performed, it will be the responsibility of the supplier to submit a specified number of test blank(s) from tungsten discs to Vought. The sub-size test blanks shall conform to ASTM E-8, Figure 6 and shall be from a single lot.

7.4.2 Tests. The first article tests shall consist of all the tests specified in test methods, 7.7.

7.5 Quality Conformance Tests

7.5.1 Sampling. Sampling for inspection and acceptance shall be performed in accordance with MIL-STD-105, except when otherwise specified herein.

7.5.2 Unit of Product. The unit of product shall be one item (as sintered) offered for acceptance.

7.5.3 Tests. The quality conformance tests shall consist of the following:

a.	Hardness	(7.5.3.1)
b.	Examination	(7.5.3.2)
c.	Density	(7.5.3.3)
d.	Porosity	(7.5.3.4)
e.	Individual Tests	(7.5.3.5)

7.5.3.1 Hardness. Each sample unit shall be tested for conformance to the hardness requirements of Table I as specified in 7.7.1. The inspection level shall be S-3 with an acceptance number of zero for all sample sizes.

7.5.3.2 Examination. Each sample unit shall be examined for dimensional and finish requirements of the drawing as specified in 6.4.

7.5.3.3 Density. Each sample unit shall be tested for conformance to the density requirements as specified in 7.7.3. The inspection level shall be S-3 with an acceptance number of zero for all sample sizes.

7.5.3.4 Porosity. The porosity level shall meet the requirements of 6.5.

7.5.3.5 Individual Tests. Unless otherwise specified a minimum of two test blanks from tungsten disc conforming to ASTM E-8 Figure 6, shall be made from each powder mix. Composition shall be tested as specified in 7.7.6 and one examination for uniformity of microstructure, 7.7.5, shall be made. Failure of any test blank to pass any one test will cause rejection of the lot represented by the test blank.

7.6 Test Conditions. The material shall be subjected to the acceptance tests under the following temperature conditions.

Room ambient, 20° to 35°C (68° to 86°F)

7.7 Test Methods.

7.7.1 Hardness. Samples shall be tested in accordance with Method 243 of Federal Test Method Standard No. 151 to determine conformance to Table II .

7.7.2 Dimension and Finish. Samples shall be inspected to determine conformance to 6.4.

7.7.3 Density. Samples shall be tested in accordance with ASTM B-311 to determine conformance to Table II.

7.7.4 Mechanical Properties. Samples shall be tested in accordance with ASTM E-8 to determine conformance to Table II with respect to tensile strength, and elongation.

7.7.5 Microstructure. This test shall be accomplished on a test blank from a disc. Metallographic examination at 200 magnifications shall show a structure having uniform distribution of tungsten and binder material.

7.7.6 Chemical Analysis. Analysis of each lot shall be made by Method 111 or 112 of Federal Test Method Standard No. 151. Chemical analysis by Method 111 shall be the basis for acceptance.

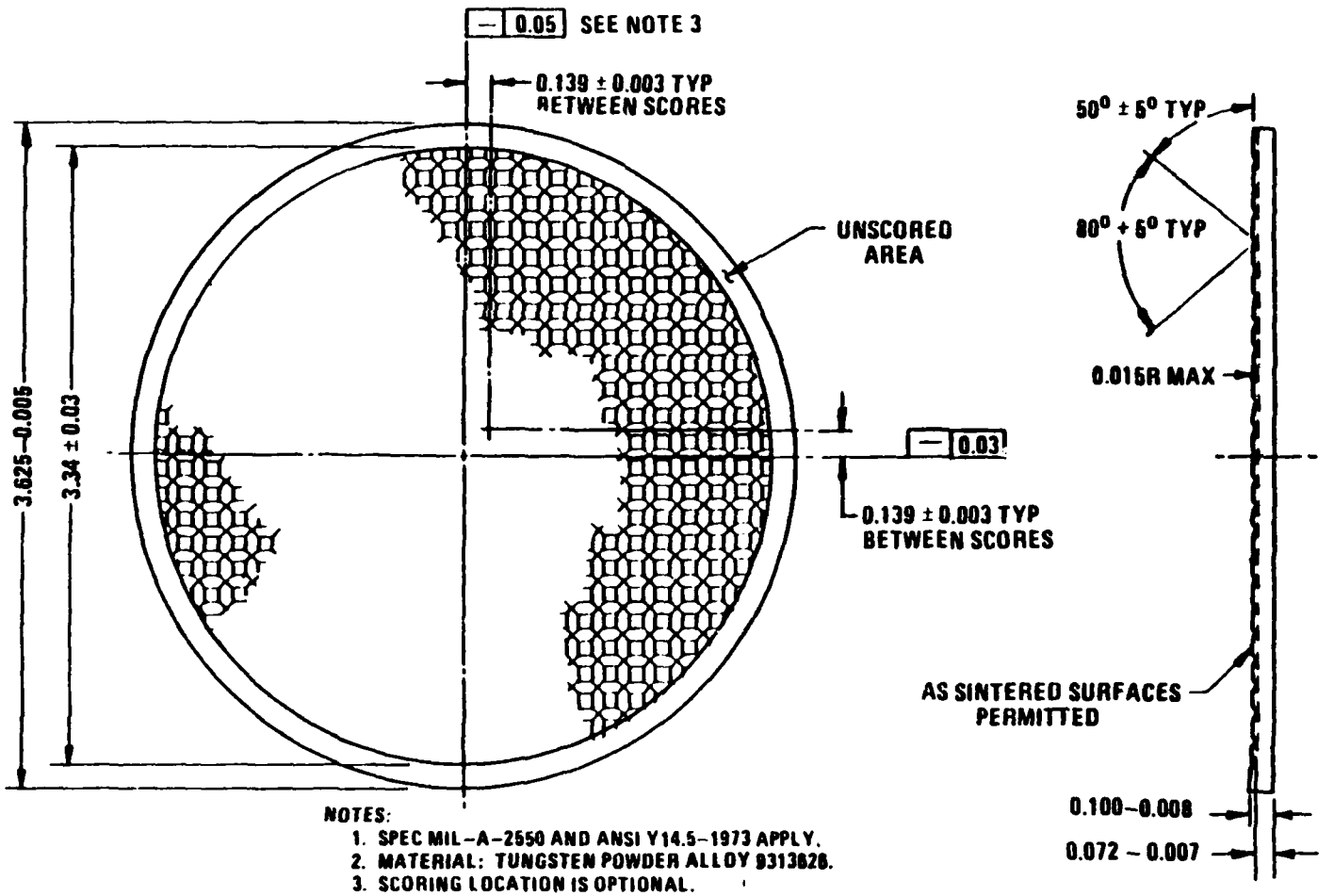
7.7.7 Penetrant Inspect (MIL-1-6866 Type I, Method A.) A minimum of ten (10) sample units shall be tested to conform to the maximum level of surface porosity when compared to a Vought supplied standard.

8. PREPARATION FOR DELIVERY

8.1 Preservation, Packaging, and Packing. Tungsten powder parts, in whatever stage of manufacturing completion as may be appropriate, shall be prepared for delivery in accordance with the contractor's commercial practice in such a manner as to insure acceptance for safe delivery by common or other carriers to the point of delivery at the lowest rate.

8.2 Marking. Each individual part and test parts shall be clearly identified with a lot serial number; where parts are too small to be individually identified, they may be grouped for this purpose. In addition, each shipment shall be marked in accordance with MIL-STD-129 (rubber stamp acceptable.)

PRESCORED TUNGSTEN ALLOY DISC (Part No. 9313567)



NOTES:
1. SPEC MIL-A-2550 AND ANSI Y14.5-1973 APPLY.
2. MATERIAL: TUNGSTEN POWDER ALLOY 9313828.
3. SCORING LOCATION IS OPTIONAL.

VOUGHT

Figure B–1.

Table B–III. Chemical and Physical Properties – Development Program

			W %	Fe %	Co %	Ni %	Cu %	Elong. %	Density g/cm^3	Rock-well (Rc)	Tensile lb/in^2
DWG 9313567 Rev. A											
			91 max	2.5-5.5	-	4.5-7.5	-	25	17.0		100,000
KENNAMETAL											
Lot #1022 Tst #1	27 Jun		90.52	3.18	.49	4.88	.94	18.0*	17.02	25-26	121,500
Tst #2								21.0*			
Lot #1022 Tst #1	18 Dec		90.04	3.19	.51	5.27	.99	18.0*	17.07	25-26	121,582
Tst #2								18.5*			127,777
Kenna. Cert Data	8 Jun		90.64	2.86	-	4.92	-	26.6	17.05	25.0	125,000
	1 Nov	Ht. Trtd	90.64	2.86	-	4.92	-	25.6-31.0	17.05	24.7	124,100
	1 Nov	as sint.	90.64	2.86	-	4.92	-	23.9-28.3	17.05	24.7	124,800
TELEDYNE FIRTH STERLING											
Lot #001 F/S Cert Data	16 Mar		90.03	3.31	-	6.66	-	25.04	17.17	26.2	133,630
Lot #132 Tst #1	2 May		90.53	2.99	trace	6.46	.017	33.8	17.19	28-28.5	127,457
Tst #2								29.6		28-28.5	129,377
F/S Cert Data			90.92	2.614	-	6.464	-	Not available			

* Letter DRDAR-PRW-B dated Nov 27, 1979 allowed a deviation on the ductility requirement for Kennametal from 25% to 18%.

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S).	
	AGENCY	NUMBER
1. TITLE Manufacturing Methods Report	Army	DI-P-1604 (Tailored)
3. DESCRIPTION/PURPOSE Manufacturing Methods Report details new or novel manufacturing methods, processes, and techniques in areas where the existing state-of-the-art does not meet military requirements.	4. APPROVAL DATE 15 Sep 83	
	5. OFFICE OF PRIMARY RESPONSIBILITY USAMC	
	6. DDC REQUIRED	
	7. APPROVAL LIMITATION	
8. APPLICATION/INTERRELATIONSHIP This data item shall not be cited in contracts where the necessary data is being secured as a part of DI-S-1300, Technical Reports, or DI-E-1118, Drawings, Engineering and Associated Lists, DI-P-1614, Description of Manufacture, or DI-E-1115, Technical Data Package.	9. REFERENCES (Source Document or Standard) AMCR 700-24	
	MCRL NUMBER	

10. PREPARATION INSTRUCTIONS

The report shall detail new manufacturing methods, processes and techniques developed under the contract. The description of the process shall include the following as minimum data:

1. Certificate of Analysis for each powder manufacturer's lot of tungsten powder.
2. Type, grade, and purity of all other metal powders, and lubricants or binders.
3. Mix composition and mixing procedure.
4. Compacting equipment (type, model, modifications, etc.) and procedure. Specific data in this category shall include powder loading and leveling method, pressure, dwell time, ejection method, and production rate.
5. Pre-sintering or delubrication procedure including specific data such as atmosphere and flow rate, furnace temperature setting(s), stoking rate, total time, and production rate.
6. Sintering equipment (type, model, modifications, etc.), and procedure. Specific data in this category shall include atmosphere and flow rate, furnace zone(s) temperature setting(s), stoking rate, total sintering time, and production rate.
7. Post-sinter heat-treating equipment (type, model, modifications, etc) and procedures, if applicable. Specific data in this category shall include heat-treating media (vacuum, atmosphere, etc.), temperature, time and production rate.
8. Forming equipment (type, model, modifications, etc.) and procedure(s). Other specific data shall include tooling drawings, tooling pre-heat temperature, disc pre-heat temperature and time, disc transfer time, press speed, and production rate.

DD FORM 1664

APPENDIX C

KENNAMETAL INC.
LATROBE, PA

CERTIFICATION OF CONFORMANCE

Kennametal Inc. hereby certifies that discs manufactured for Vought Corporation on Purchase Order Number MOP-136133, Shop Order Number #901-1253 conform to the requirements as specified on Drawing Number 9313567 (Rev. A).

Material W-10 Lot Number 1022 Quantity 11

Lot 1022

Chemical Composition

Tungsten	90.64
Nickel	4.92
Iron	2.86
Total other elements	1.58%

Physical Properties

	Required	Actual
Density (g/cc)	17.0 min.	17.05
Hardness (Rc)	32 max.	25.0

Tensile (flat rectangular tension test specimen - ASTM E8 Figure 6 Subsize - ¼" wide - 1" Gauge)

Ultimate Strength (Psi)	100,000 min.	125,000
Elongation (%)	25.0 min.	26.6%

200X Microstructure Normal

Attested by

Alden M. Burghardt Signature

Alden M. Burghardt Name
Manager of Metallurgical Development Title

June 8, 1979 Date

KENNAMETAL INC.
LATROBE, PA

CERTIFICATION OF CONFORMANCE

Kennametal Inc. hereby certifies that discs manufactured for Vought Corporation on Purchase Order Number MOP-136133, Shop Order Number #901-1253 conform to the requirements as specified on Drawing Number 9313567 (Rev. A).

Material W-10 Lot Number 1022 Quantity 11

Dimensional Inspection: Parts meet all the required specfications, except for the following.

The .100" thickness is oversize .001/.002" on 25% of surface.

The .139 ± .003" dimension is undersize by .001" on three pieces.

ATTESTED BY:

Al Augustine SIGNATURE

Al Augustine NAME

Supervisor Quality Assurance TITLE

June 8, 1979 DATE

KENNAMETAL INC.
LATROBE, PA

CERTIFICATION OF CONFORMANCE

Kennametal Inc. hereby certifies that discs manufactured for Vought Corporation on Purchase Order Number MDP-136133, Shop Order Number #901-1253 conform to the requirements as specified on Drawing Number 9313567 (Rev. A).

Material W-10 Lot Number 1022 Quantity 49

Lot 1022 (As-sintered)

Chemical Composition

Tungsten	90.64
Nickel	4.92
Iron	2.86
Total other elements	1.58%

Physical Properties

	Required	Actual
Density (g/cc)	17.0 min.	17.05
Hardness (Rc)	32 max.	24.7

Tensile (flat rectangular tension test specimen - ASTM E8 Figure 6)

Subsize - ¼" wide - 1" Gage

Ultimate Strength (Psi)		100,000 min.	124,800
*Elongation (%)	1" Gage	25.0 min.	23.9
	½" Gage		28.3

200X Microstructure Normal

Attested by

G.C. Tokesky Signature

George C. Tokesky Name

Manager, Metallurgical Services Title

November 1, 1979 Date

*Elongation determined on same specimen

KENNAMETAL INC.
LATROBE, PA

CERTIFICATION OF CONFORMANCE

Kennametal Inc. hereby certifies that discs manufactured for Vought Corporation on Purchase Order Number MDP-136133, Shop Order Number #901-1253 conform to the requirements as specified on Drawing Number 9313567 (Rev. A).

Material W-10 Lot Number 1022 Quantity 47

Lot 1022 (As-sintered)

Chemical Composition

Tungsten	90.64
Nickel	4.92
Iron	2.86
Total other elements	1.58%

Physical Properties

	Required	Actual
Density (g/cc)	17.0 min.	17.05
Hardness (Rc)	32 max.	24.7

Tensile (flat rectangular tension test specimen - ASTM E8 Figure 6)

Subsize - ¼" wide - 1" Gage

Ultimate Strength (Psi)		100,000 min.	124,800
*Elongation (%)	1" Gage	25.0 min.	23.9
	½" Gage		28.3

200X Microstructure Normal

Attested by

G.C. Tokesky Signature

George C. Tokesky Name

Manager, Metallurgical Services Title

November 1, 1979 Date

*Elongation determined on same specimen

APPENDIX D

TELEDYNE FIRTH STERLING

PRE-SCORED TUNGSTEN DISCS

MANUFACTURING METHODS REPORT

I. TUNGSTEN DISCS COMPOSITION CHARACTERISTICS

A. Analytical Report - Lot No. 131 - Material X-29, Sample 3

B. Certificate of Analysis - Tungsten Powder - Lot No. C-8-6133-FS

C. Analytical Report - Lot No. 132 - Material X-29

D. Analytical Report - Lot No. 4399 - Material Reduced Tungsten For Blend 132

E. Analytical Report - Lot No. 403 - Material Nickel Powder

F. Analytical Report - Lot 605 - Iron Powder

G. Gulf Oil Corporation - Typical Properties Gulfwax 27

H. Compacting Punch Design

II. CERTIFICATE OF TEST AND COMPLIANCE - LOT 131

III. COMPOSITION FORMULA

A. Tungsten - 90.3 $\pm$ .5%

B. Nickel - 7 $\pm$ .5%

C. Iron - 3 $\pm$ .3%

D. Other Permissable - .5%

DYNE
H STERLING
PARKWAY CENTER
PITTSBURGH, PA.

ANALYTICAL REPORT

DATE 3-16-79

REPORT NO. 0005

SAMPLE REFERENCE:

CUSTOMER REFERENCE:

SUBMITTED BY: VERN SHOTWELL

John Sieverling
(Operator)

James Bost
Quality Control Manager

ANALYSIS

MATERIAL X-29, SAMPLE 3 LOT NO. 131

PHYSICAL

	As Supplied	Lab Milled	
Fisher No. Av. Microns			
Porosity			
Scott Density			gm/cu. in.
Tap Test			gm/cm³
Hall Flow Test			sec.

PARTICLE SIZE DISTRIBUTION BY X-RAY SEDIGRAPH (LAB MILLED)

Micron Range	Wt %	Micron Range	Wt %
0-1		7-8	
1-2		8-9	
2-3		9-10	
3-4		10-15	
4-5		15-20	
5-6		20-25	
6-7		Balance	

SCREEN ANALYSIS

MESH SIZE	Wt %

CHEMICAL and SPECTROGRAPHIC

ELEM.	%	ELEM.	%
AL		N	
As		Na	
B		Ni	6.56
C_T		O	
C_F		P	
C_C		Pb	
Ca		S	
Cb		Sb	
Co		Si	
Cr		Sn	
Cu		Ta	
Fe	3.35	Ti	
Mg		W	BAL. 90.1
Mn			
Mo			

COMMENTS:

PARAFFIN REMOVED W/ HEXANE

TELEDYNE
WAH CHANG HUNTSVILLE
7300 HIGHWAY 20 WEST HUNTSVILLE, ALABAMA 35806
(205) 837-1311 TWX 810-726-2225

CERTIFICATE OF ANALYSIS

To.: Teldyne Firth Sterling
P.O.Box 700
McKeesport, PA 15134

Attn: Mr. Don Bernens

Date January 17, 1979

Quantity 500 Lbs./Kgs.

Customer Order No. 13835

Wah Chang Order No. HA-1916

Joyce Taylor for Robert V. Pi
Quality Control Manager

ANALYSIS

MATERIAL Tungsten Powder LOT NO. C-8-6133-FS

PHYSICAL

	As Supplied	Lab Milled	
Fisher No. Av. Microns	3.15	2.52	
Porosity	0.661	0.550	
Scott Density	49.32	gm/cu. in.	
Tap Test	6.250	gm/cm³	

PARTICLE SIZE DISTRIBUTION BY PHOTOTELOMETER (LAB MILLED)

Micron Range	Wt. %	Micron Range	Wt. %
0-1	9.5	7-8	5.2
1-2	18.4	8-9	4.2
2-3	17.8	9-10	2.6
3-4	15.1	10-15	
4-5	11.2	15-20	
5-6	9.7	20-25	
6-7	6.3	Balance	

SCREEN ANALYSIS

MESH SIZE	Wt. %
-200	100

CHEMICAL and SPECTROGRAPHIC

ELEM.	%	ELEM.	%
AL	-0.001	N	
As		Na	
B		Ni	-0.001
C_T	0.0025	O	0.0232
C_F		P	
C_C		Pb	-0.001
Ca	-0.001	S	
Cb		Sb	
Co	-0.001	Si	-0.003
Cr	-0.003	Sn	-0.001
Cu	-0.001	Ta	
Fe	-0.004	Ti	-0.001
Mg	-0.001	W	
Mn	-0.001		
Mo	-0.005		

cc Mr. Andy Bodnar
Mr. Robert Painter

TELEDYNE
FIRTH STERLING
4 PARKWAY CENTER
PITTSBURGH, PA.

ANALYTICAL REPORT

DATE 4-4-79

REPORT NO. 0042

SAMPLE REFERENCE:

CUSTOMER REFERENCE:

SUBMITTED BY: ROBIN HELENDEZ

John Sewerling
(Operator)

Quality Control Manager

ANALYSIS

MATERIAL X-29 LOT NO. 132

PHYSICAL

	As Supplied	Lab Milled	
Fisher No. Av. Microns			
Porosity			
Scott Density			gm/cu. in.
ρ Test			gm/cm³
Hall Flow Test			sec.

PARTICLE SIZE DISTRIBUTION BY X-RAY SEDIGRAPH (LAB MILLED)

Micron Range	Wt. %	Micron Range	Wt. %
0-1		7-8	
1-2		8-9	
2-3		9-10	
3-4		10-15	
4-5		15-20	
5-6		20-25	
6-7		Balance	

SCREEN ANALYSIS

MESH SIZE	Wt. %

CHEMICAL and SPECTROGRAPHIC

ELEM.	%	ELEM.	%
AL		N	
As		Na	
B		Ni	6.464
C_T		O	
C_F		P	
C_C		Pb	
Ca		S	
Cb		Sb	
Co		Si	
Cr		Sn	
Cu	>5ppm	Ta	
Fe	2.614	Ti	
Mg		W	
Mn			
Mo			

COMMENTS:

TELEDYNE
FIRTH STERLING
4 PARKWAY CENTER
PITTSBURGH, PA.

ANALYTICAL REPORT

DATE 4-4-79

REPORT NO. 0043

John Severling
(Operator)

SAMPLE REFERENCE:

CUSTOMER REFERENCE:

SUBMITTED BY: ROBIN MELENDEZ

Quality Control Manager

ANALYSIS

MATERIAL REDUCED TUNGSTEN LOT NO. 4399 For Blend 132

PHYSICAL	As Supplied	Lab Milled
Fisher No. Av. Microns	2.60	
Porosity	.670	
Scott Density	gm/cu. in.	
ρ Test	gm/cm³	
Hall Flow Test	sec.	

PARTICLE SIZE DISTRIBUTION BY X-RAY SEDIGRAPH (LAB MILLED)

Micron Range	Wt. %	Micron Range	Wt. %
0-1		7-8	
1-2		8-9	
2-3		9-10	
3-4		10-15	
4-5		15-20	
5-6		20-25	
6-7		Balance	

SCREEN ANALYSIS

MESH SIZE	Wt. %

CHEMICAL and SPECTROGRAPHIC			
ELEM.	% *	ELEM.	% *
AL	99ppm	N	
As		Na	4.9ppm
B		Ni	
C_T		O	
C_F		P	
C_C		Pb	
Ca		S	
Cb		Sb	
Co		Si	239ppm
Cr		Sn	
Cu		Ta	
Fe		Ti	
Mg		W	
Mn			
Mo			

* COMMENTS: UNLESS OTHERWISE NOTED

TELEDYNE
FIRTH STERLING
4 PARKWAY CENTER
PITTSBURGH, PA.

ANALYTICAL REPORT

DATE 4-25-79

REPORT NO. 0061

SAMPLE REFERENCE:

CUSTOMER REFERENCE:

SUBMITTED BY:

John Sieverling
(Operator)

James Bost
Quality Control Manager

ANALYSIS

MATERIAL NICKEL POWDER LOT NO. 403

PHYSICAL

	As Supplied	Lab Milled
Fisher No. Av. Microns	4.60	
Porosity	.635	
Scott Density	gm/cu. in.	
Tap Test	gm/cm³	
Hall Flow Test	sec.	

PARTICLE SIZE DISTRIBUTION BY X-RAY SEDIGRAPH (LAB MILLED)

Micron Range	Wt. %	Micron Range	Wt. %
0-1		7-8	
1-2		8-9	
2-3		9-10	
3-4		10-15	
4-5		15-20	
5-6		20-25	
6-7		Balance	

SCREEN ANALYSIS

MESH SIZE	Wt. %

CHEMICAL and SPECTROGRAPHIC

ELEM.	%	ELEM.	%
AL		N	
As		Na	5 ppm
B		Ni	
C_T		O	
C_F		P	
C_C		Pb	
Ca	<1 ppm	S	
Cb		Sb	
Co		Si	
Cr		Sn	
Cu		Ta	
Fe		Ti	
Mg		W	
Mn		K	<1 ppm
Mo			

COMMENTS:

TELEDYNE
FIRTH STERLING
4 PARKWAY CENTER
PITTSBURGH, PA.

ANALYTICAL REPORT

DATE 4-25-79

REPORT NO. 0060

SAMPLE REFERENCE:

CUSTOMER REFERENCE:

SUBMITTED BY:

John Swerling
(Operator)

James Bott
Quality Control Manager

ANALYSIS

MATERIAL Iron Powder LOT NO. 605

PHYSICAL	As Supplied	Lab Milled
Fisher No. Av. Microns	4.80	
Porosity	.615	
Scott Density		gm/cu. in.
Tap Test		gm/cm³
Hall Flow Test		sec.

CHEMICAL and SPECTROGRAPHIC			
ELEM.	%	ELEM.	%
AL		N	
As		Na	
B		Ni	
C_T	.023	O	
C_F		P	
C_C		Pb	
Ca		S	
Cb		Sb	
Co		Si	
Cr		Sn	
Cu		Ta	
Fe		Ti	
Mg		W	
Mn			
Mo			

PARTICLE SIZE DISTRIBUTION
BY X-RAY SEDIGRAPH (LAB MILLED)

Micron Range	Wt. %	Micron Range	Wt. %
0-1		7-8	
1-2		8-9	
2-3		9-10	
3-4		10-15	
4-5		15-20	
5-6		20-25	
6-7		Balance	

SCREEN ANALYSIS	
MESH SIZE	Wt. %

COMMENTS:

Typical Properties

	Gulfwax 20	Gulfwax 27	Gulfwax 33	Gulfwax 40
Gravity, ASTM D 287: °API Theoretical	43.8	43.5	42.4	41.3
Melting Point, ASTM D 87: F	120.2	126.6	131.8	140.1
ASTM D 127: F	—	—	—	—
Congealing Point, ASTM D 938: F	120	127.8	135.0	138
Penetration, ASTM D 1321 @ 77 F	17	18	15	14
@ 100 F	74	58	56	40
Viscosity, SUS @ 150 F	42.7	44.7	49.4	—
@ 180 F	—	—	—	46.8
@ 210 F	35.9	36.8	39.2	41.6
Flash, OC: F	400	400	430	455
Cloud Point, ASTM D 97: F	146	146	—	—
Color, Saybolt	+30	+30	+30	+30
Color, ASTM D 1500	—	—	—	—
Odor, Solid State	v. slight	v. slight	v. slight	slight
Liquid State	v. slight	v. slight	v. slight	v. slight
Oil Content, ASTM D 721: %	0.29	0.18	0.19	0.15
Tensile Strength, ASTM D 1320: PSI	280	300	398	352
Modulus of Rupture, TAPPI-655: PSI	358	389	—	422
Oxidation Stability Test, 275 F Proposed ASTM Method (1955) Induction Period: Minutes	647	700	705	749
Ultraviolet Absorptivity @ 290 mμ, ASTM D2008	<0.01	<0.01	<0.01	<0.01
API Classification	Type I	Type I	Type I	Type I
Blocking Point, ASTM D 1465				
Picking Point: F	92	96	—	99
Blocking Point: F	93	98	98	108
Iodine Number	0.2	0.2	0.37	0.4
Molecular Weight	326	346	373	442
Refractive Index	1.4285	1.4343	1.4330	1.4359
Distillation, Vacuum Corrected to 760 mm Hg				
5% Point: F	724	724	747	804
10%	728	730	749	810
50%	748	748	765	844
70%	760	758	770	865
90%	786	786	799	896

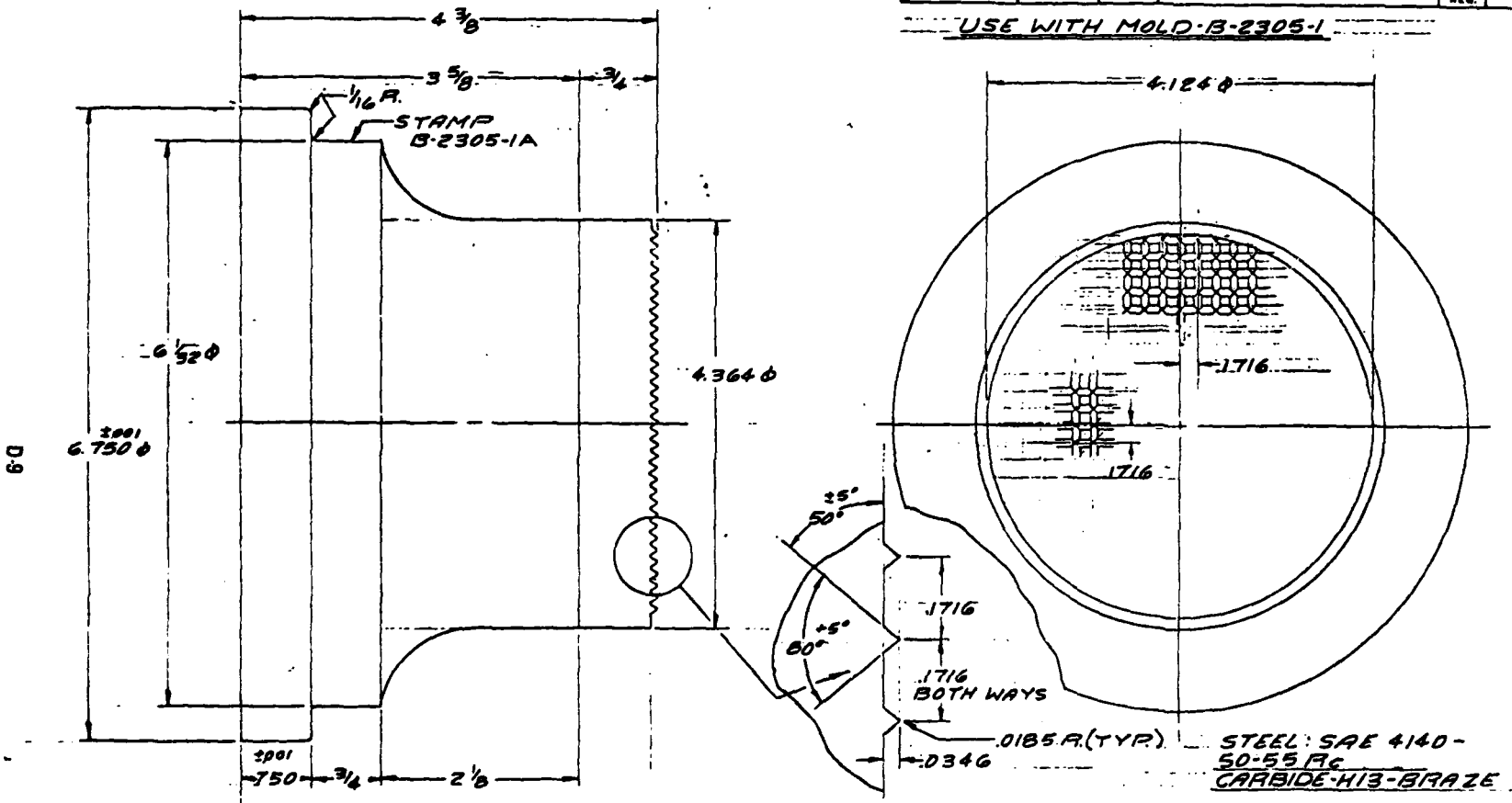
SP 10718—DM—63

Gulf Oil Corporation
Gulf Building

DWG. NO. B-2305-1A

BILL OF MATERIAL					
DWG. No.	REQ. No.	ITEM	DESCRIPTION	NO. REQ.	MATL

USE WITH MOLD-B-2305-1



STEEL: SAE 4140 - 50-55 Rc
CARBIDE-H13-BRAZE

PROJECT AUTHORIZATION

WORK ORDER No.

TOLERANCE	
FRACTIONAL DIMENSIONS	± 1/32
DECIMAL DIMENSIONS	± .001
ANGULAR DIMENSIONS	± 1°
UNLESS OTHERWISE SPECIFIED	

REVISIONS			
SYM.	DESCRIPTION	DATE	BY

TELEDYNE FIRTH STERLING

TITLE- TOP PUNCH .200 TON PRESS

DIVISION CARBIDE
DEPT. PRESS ROOM
DRAWN BY RS
DATE 9-10-79
CHECKED BY
SCALE FULL
APPROVED BY
APPROVED BY
DWG. NO. B-2305-1A

TELEDYNE
FIRTH STERLING

#1 TELEDYNE PLACE
INTERCHANGE CITY IND. PARK
LA VERGNE, TENNESSEE 37086
(615) 793-7771

March 19, 1979

CERTIFICATE OF TEST AND COMPLIANCE

Vought Corporation
38111 Van Dyke Avenue
Sterling Heights, Mich. 48077

Description: Tungsten Base, High Density Metal Disc

Physicial and Mechanical Properties:

UTS	100,000 psi (min.)
Elongation	25% (min.)
Density	17.0 gm/cm^3 (min.)
Hardness	32 R_C (max.)

Results to be obtained by ASTM E-8, Figure 6 Tensile Specimen.

I certify that the physical and mechanical properties of said material according to the above description, are as follows for Lot 131:

UTS	133,630 psi
Elongation	25.04%
Density	17.17 gm/cm^3
Hardness	26.2 R_C

TELEDYNE FIRTH STERLING

By: _____
ROBIN J. MELENDEZ
METALLURGIST

By: _____
EARL R. PHILLIPS
DCAS QAR

APPENDIX E

Mr. Cuda/db/
201-328-6455

DRDAR-PRW-B

NOV 2 7 1979

Vought Corporation
Michigan Division
ATTN: D. W. McMillan, Contracts
38111 Van Dyke Ave.
Sterling Heights, MI 48077

Gentlemen:

Reference is made to Contract DAAK10-79-C-0049.

The ductility requirement on Drawing 9313567, Tungsten Disc, is lowered to 18%. This item is currently being furnished to Vought Corporation by Kennametal Company under the above-referenced contract.

Parts from the above-referenced contract which are considered unsuitable for loading because of cracks and/or dimensional deviations shall be shipped to U.S. Army ARRADCOM, ATTN: DRDAR-SCM-P, Mr. W. Sheldon, Dover, N.J. 07801.

It is understood that the above changes shall have no impact on contract cost or delivery schedule.

Sincerely yours,

SAMUEL F. RIZZO
Contracting Officer

CF:
DCASMA Detroit
McNamara Fed Bldg
477 Michigan Ave.
Detroit, MI 48226

TELEDYNE
FIRTH STERLING

#1 TELEDYNE PLACE
INTERCHANGE CITY IND. PARK
LA VERGNE, TENNESSEE 37086
(615) 793-7771

March 21, 1979

LETTER OF AGREEMENT

TUNGSTEN DISCS

REF: (1) Material Specification for Tungsten Base, High Density Metal Discs, 707-11

(2) Disc, Tungsten T9313567 Rev. A

1. The first article inspection at Teledyne Firth Sterling occured on March 20, 1979 and was witnessed by Vought and ARRADCOM personnel.

   The 32 discs met all of the requirements referenced in 1 and 2 except the surface finish and dye penetrant requirement level when compared to the Vought supplied standard.

2. It has been mutually decided to conditionally accept this initial quantity of discs based on successful forming by Vought.

3. These discs do not constitute first article acceptance; therefore, Vought tentatively waives first article and in-plant inspection is not required for this quantity.

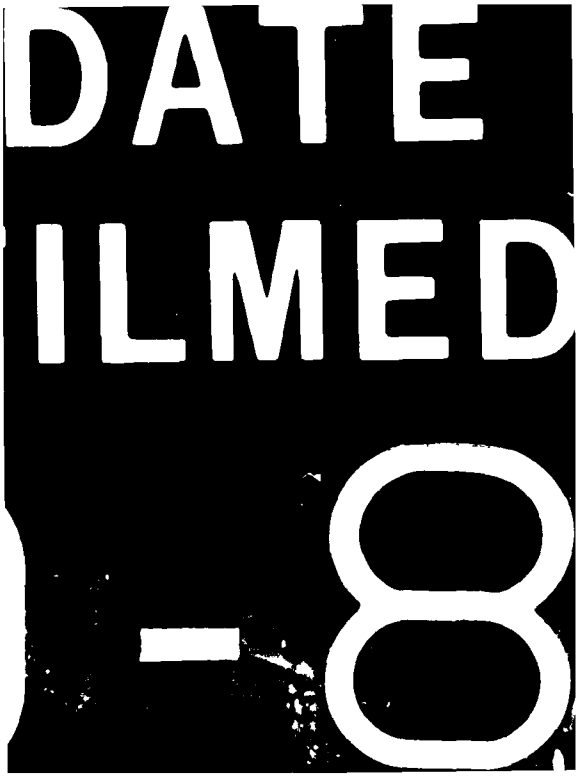
SIGNED:

Vern Shotwell
VERN SHOTWELL
TELEDYNE FIRTH STERLING
PROJECT ENGINEER

Syd Gordon
SYD GORDON
ARRADCOM
PROJECT OFFICER

W. Mrdeza
W. MRDEZA
VOUGHT CORPORATION
PROJECT MANAGER

William Sheldon
WM. SHELDON
ARRADCOM
METALLURGIST


DATE
ILMED
-8